COMPARING F-16 MAINTENANCE SCHEDULING PHILOSOPHIES

THESIS

Konstantinos Iakovidis, Major, HAF
AFIT/GLM/ENS/05-12

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GLM/ENS/05-12

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Konstantinos Iakovidis

Major, HAF

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Konstantinos Iakovidis
Major, HAF

Approved:

/signed/

John Bell, Maj (USAF) (Advisor) date

/signed/

Stanley Griffis, Lt Col (USAF) (Reader) date

/signed/

Victor Wiley, Maj (USAF) (Reader) date

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Abstract

In the F-16 fighter community it is believed that the flying schedule can make or break a wing's maintenance effort. Nevertheless, there is no published scientific support behind many commonly used maintenance scheduling philosophies. For example, not everyone agrees that routinely flying only one "go" on the last day of the week enhances the long term maintenance health of the fleet. Subsequently, justification for choosing one scheduling philosophy over another cannot occur. The problem is that a generally accepted overall scheduling philosophy to improve the long term health of the fleet does not exist.

The purpose of this research is tri-fold: first of all, the most important scheduling philosophies are identified using a Delphi study; second, the more meaningful metrics that capture the long term health of the fleet and maintenance effectiveness are identified in the Delphi study and by using a content analysis; and third, the various philosophies are tested using the performance measures to help maintenance managers choose the most appropriate one. For the last step of the study, a stochastic simulation model was generated to model the sortie generation process, and a full factorial Design of Experiment was used to identify statistically significant differences among the proposed scheduling philosophies. The results of the study show that the "3 waves Monday through Thursday and 1 wave on Friday" maintenance scheduling philosophy seems to outperform the other philosophies regardless of the sortie surge level or the time between

landing and take off. This philosophy is also less sensitive than the alternative philosophies in sortie level and time between landing and take-off changes.

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COMPARING F-16 MAINTENANCE SCHEDULING PHILOSOPHIES

I. Introduction

Background

In the F-16 fighter community it is believed that the flying schedule can make or break a wing's maintenance effort. Nevertheless, there is no published scientific support behind many commonly used maintenance scheduling philosophies. For example, not everyone agrees that routinely flying only one "go" on the last day of the week enhances the long term maintenance health of the fleet. Unfortunately, there is little scientific validation to back up the opinions of officers about scheduling philosophies when disagreement arises over their usefulness by both advocates and detractors. Without this validation, the potential outcome of the various scheduling philosophies cannot be quantitatively determined. Subsequently, justification for choosing one philosophy over another cannot occur. Even those beliefs that appear intuitive should be validated by scientific study.

Problem Statement

A generally accepted single overall scheduling philosophy to improve the long term health of the fleet does not exist. By statistically comparing common F-16 fighter unit scheduling philosophies, this study seeks to identify which practices will improve the

long term health of the fleet and effectively enable maintenance to meet long term unit sortie production goals.

Research Question

Which F-16 fighter unit scheduling philosophy achieves the best long term health of the fleet and most effectively enables maintenance to meet unit sortie production goals?

Investigative Questions

The following questions are addressed in order to answer the research question:

1. What are the commonly used F-16 unit scheduling philosophies that need to be compared in terms of improving the long term health of the fleet?
2. What are the important performance metrics that the USAF uses to capture the long term health of the fleet and maintenance effectiveness to meet unit sortie production goals?
3. How does each one of the various scheduling philosophies affect the long term health of the fleet and maintenance effectiveness to meet unit sortie production goals?
4. Is there statistical evidence that one of the philosophies is better than the others and under what situations?

Proposed Methodology

Scheduling Philosophies (Question 1).

The commonly used F-16 unit scheduling philosophies that need to be compared in terms of improving the long term health of the fleet were identified by using sponsor's

(354 AMXS/CC, Eielson AFB) and personal experience[1], and by conducting a Delphi method study of expert beliefs on best maintenance scheduling philosophies of maintenance officers assigned at Air Force Institute of Technology (AFIT). The participants of the Delphi method were limited to maintenance officers assigned to AFIT due to survey restrictions. Although this was frustrating initially, the responses were interesting, came from people with variety of experience, and finally they were useful for conducting the study. This information was used to identify a list of the different philosophies that were tested later in the research.

The Delphi method was used to develop a group consensus of the most commonly used maintenance scheduling philosophies. Three iterations were conducted and a partial consensus[2] was achieved. During the first questionnaire (replying to essay type questions) many useful ideas (based on individual experiences) arose. The same Delphi method was also used to answer part of second and third investigative questions.

Performance Metric (Question 2).

The second investigative question required some more archival research. The Maintenance Metrics Handbook (AFLMA, 2002), describes the metrics used by the USAF for assessing the health of the F-16 fleet. In addition to this handbook, many former AFIT students have utilized various metrics in their theses' research. The more meaningful metrics related to the research question were carefully selected depending upon the literature review, expert's belief (utilizing the Delphi method described above)

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[1] Researcher has 11 years experience in F-16 maintenance. He worked in flight line, quality control, phased inspections and as a chief of maintenance in a Hellenic F-16 Squadron.

[2] Delphi consensus will be addressed in Chapter IV

and personal experience. The initial questionnaire of the Delphi method requested opinions for extra metrics (beyond those described in maintenance metrics handbook) that could be useful in the third and fourth investigative questions while comparing the various alternative scheduling philosophies.

Collection and Analysis (Questions 3 and 4).

Once the philosophies and the performance measures had been identified, a stochastic simulation model was built (in Arena® 7.1) to simulate the different philosophies. The model was created as parametric as possible to enable the use of the Design of Experiments (DOE) approach to determine the most influential factors and to assess if statistically significant differences exist between them. Historical data from Eielson AFB were analyzed to estimate the model input parameters. These parameters were validated by Subject Matter Experts (SMEs) to enhance external validity (generalization) of the research. Additionally, Eielson's AFB manning data were used in a parametric format that can be easily altered if implementation to other airfields is needed.

Scope and limitations

The scope of this research is tri-fold: first of all, the most important scheduling philosophies are identified; second, the more meaningful metrics that capture the long term health of the fleet and maintenance effectiveness are identified; and third, the various philosophies are tested using the performance measures to help maintenance managers choose the most appropriate one.

Several assumptions were made during this research that can be categorized as follows:

Delphi Method Assumptions.

It is assumed that the AFIT students that participated in the Delphi study were subject matter experts. Keeping in mind that the key to a successful Delphi study lies in the selection of participants, it is assumed that only knowledgeable persons were included in the study[3].

Model assumptions.

The model simulates the F-16 aircraft sortie generation operations and its scope is to cover in detail the aircraft scheduling process. For example, the entire supply system was not modeled, but a careful approach was taken not to influence the answer to the investigative questions themselves. Therefore, the assumptions or un-modeled pieces do not dictate the solutions. Manpower was modeled using Eielson AFB's data and no assumptions needed to be made about manning. Aircraft do not fly and personnel do not work during weekends (per Eielson's guidance). Also, surge periods (periods when the flying schedule is above normal for training purposes under pressure to produce the required sorties) and hot pits (consecutive sorties without shutting down the engines -- only refueling takes place) were simulated in the model (no assumptions). Aircraft failures were assumed to be random and were uniformly assigned to tail numbers (constant reliability across different tail numbers). Failure data for one year were

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[3] To increase generalizability, approval was requested to include participants from outside of AFIT in the Delphi study, but it was disapproved. However, while soliciting for participation in the research process, only experienced maintenance managers were asked to volunteer. This requirement helped to establish the needed experts for the Delphi Study.

analyzed from Eielson AFB, and empirical (and some theoretical were appropriate) distributions were assigned to failure durations (continuous) and crew sizes (discrete). It was assumed that the provided CAMS data were accurate. Stetz (1999) and Commenator (2001) in addressing this subject in their research, realized that although there is a minimal rate of inaccuracy, CAMS data are the most accurate data available within Air Force. In addition, it was assumed that each jet will have either one or no-write-ups after flights. If two or more write ups were incorporated, the model would have been exponentially complicated (re-routing entities through the assignment of failures -- specialty, duration, crew size-- and working to eliminate them) without ameliorating the results. That is because the calculated statistics are independent of tail numbers, and in the real world, only one failure is being worked at a time on each aircraft.

Various states of the aircraft were not simulated (i.e. partial mission capable -- only able to perform certain type of missions). However, aircraft cannibalization was incorporated since the Delphi study results proposed that cannibalization is very important constraint in maintenance effectiveness. Additionally, the “assigning aircraft to missions” process is an area where assumptions were made; a FIFO (First In First Out) approach (the first “ready to fly” aircraft is assigned to next mission) was assumed. However, in the real world, different approaches are usually used (aircraft is assigned to a mission based on its configuration, type of mission, accomplished TCTO’s, its reliability, its remaining flying hours until scheduled inspection, etc.). Also, different configurations, blocks, and technologies were assumed constant for all F-16s in the model.

Summary

Chapter I has provided an overview of the research effort, the problem statement and objective of this research, and the proposed investigative questions and related methodology which will lead to the successful accomplishment of the research objective. Chapter II presents an in-depth review of the existing literature on this subject. Chapter III describes the Delphi study, the content analysis, the development of the model, and the data used to meet the research objective. Chapter IV provides the findings of the study, and Chapter V provides conclusions and presents areas for further research.

II. Literature Review

Introduction

This chapter summarizes the literature used to aid in determining the various scheduling philosophies and their impact to long term health of the fleet. The literature review includes the following areas: the sortie generation process and the flexibility that it provides to managers to apply different scheduling philosophies, the maintenance metrics that the USAF uses and how they are related to research question, and other simulation projects in the area of sortie generation.

Sortie generation process

This section describes the sortie generation process as it appears in various instructions and manuals of the USAF. The main objective of this portion of the literature review is to define and describe the conceptual model that is presented in Figure 1.

The flight line maintenance process involves many activities. This includes aircraft launch and recovery, inspections, servicing, and periodic maintenance, to name a few. Figure 2 shows a typical maintenance process from the time an aircraft lands until it is launched for its next mission. Many of these activities occur simultaneously, though the basic process is circuitous (AFLMA, 1995). AFI 21-101 (DAF, 2002) is the basic Air Force directive for aircraft and equipment maintenance management. It provides the minimum essential guidance and procedures for safely and effectively maintaining, servicing, and repairing aircraft and support equipment at the base level. It applies to all major commands (MAJCOMs) and their subordinates. It provides guidelines for servicing, inspections, and maintenance, and ensures all mobility requirements are met. It

defines aircraft generation as the cumulative effort required to launch and recover sorties. It includes activities that generate and train personnel to generate sorties. A typical sortie generation sequence usually begins with recovery of an aircraft from another mission. Because aircraft recovery and generation activities are directly related, aircraft recovery is the first step in aircraft generation.

Aircraft technicians ensure mission accomplishment by launching and recovering aircraft. During the launch and recovery of aircraft, deficiencies might be identified on aircraft. During parking and recovery, the aircraft is prepared for ground operations, and aircraft servicing commences. This servicing includes checking fluid levels and refueling the aircraft. During the aircrew debriefing, involving the aircrew and maintenance personnel, any discrepancies are discussed, documented, and placed into a computerized information system. In the case of F-16, the Core Automated Maintenance System (CAMS) is used. Next, if required, a maintenance crew heads to the aircraft to conduct the repair and to return the aircraft to operational status. This is referred to as unscheduled maintenance since these faults occur over the course of the sortie mission, meaning maintenance was unplanned.

The next step may involve preventive maintenance and periodic inspections, Time Compliance Technical Order installations, system calibrations, and Time Change Item (TCI) replacements. TCI part replacements are based on accumulated flight hours, not on part condition.

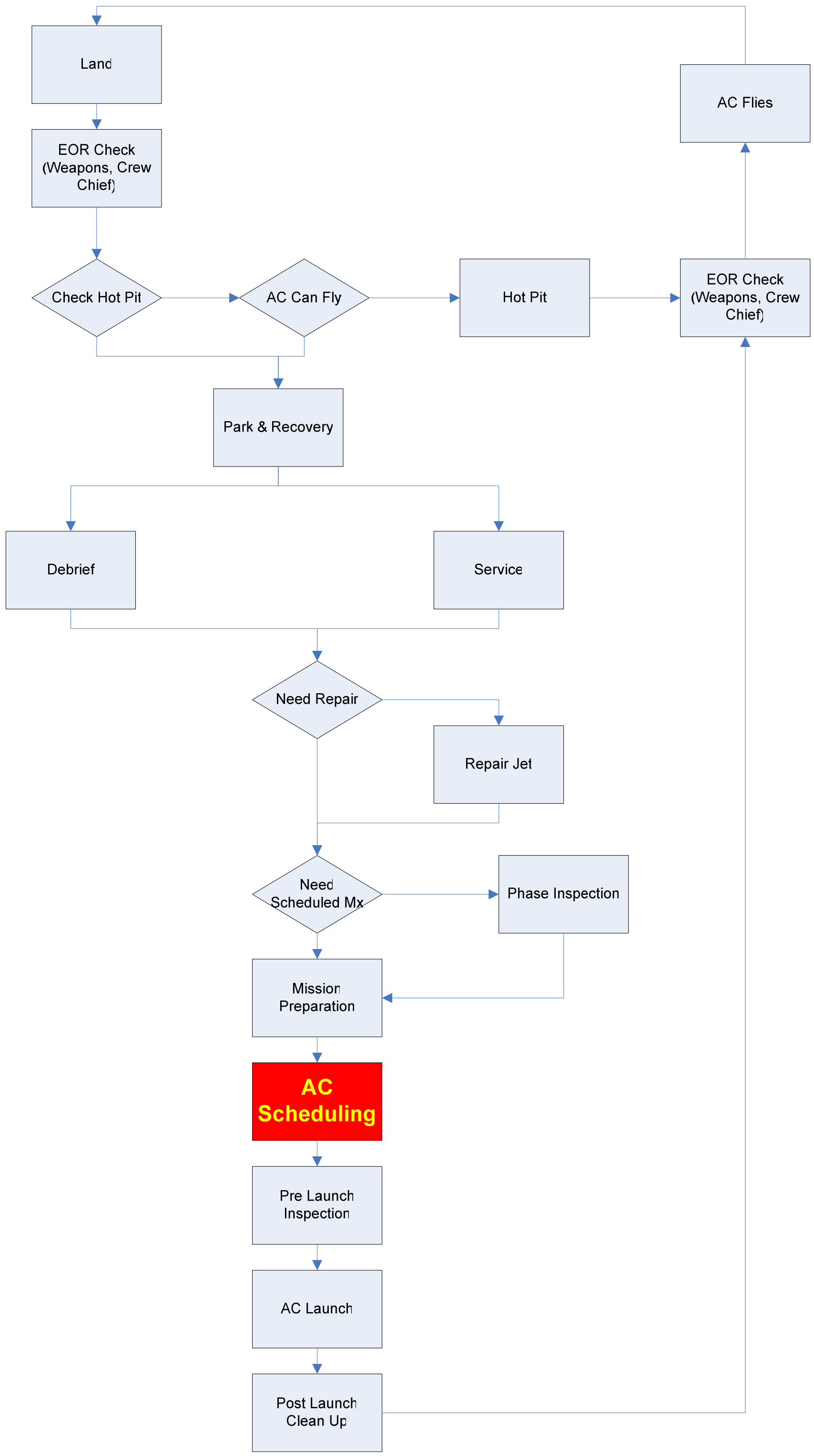


Figure 1. Conceptual Model describing sortie generation process

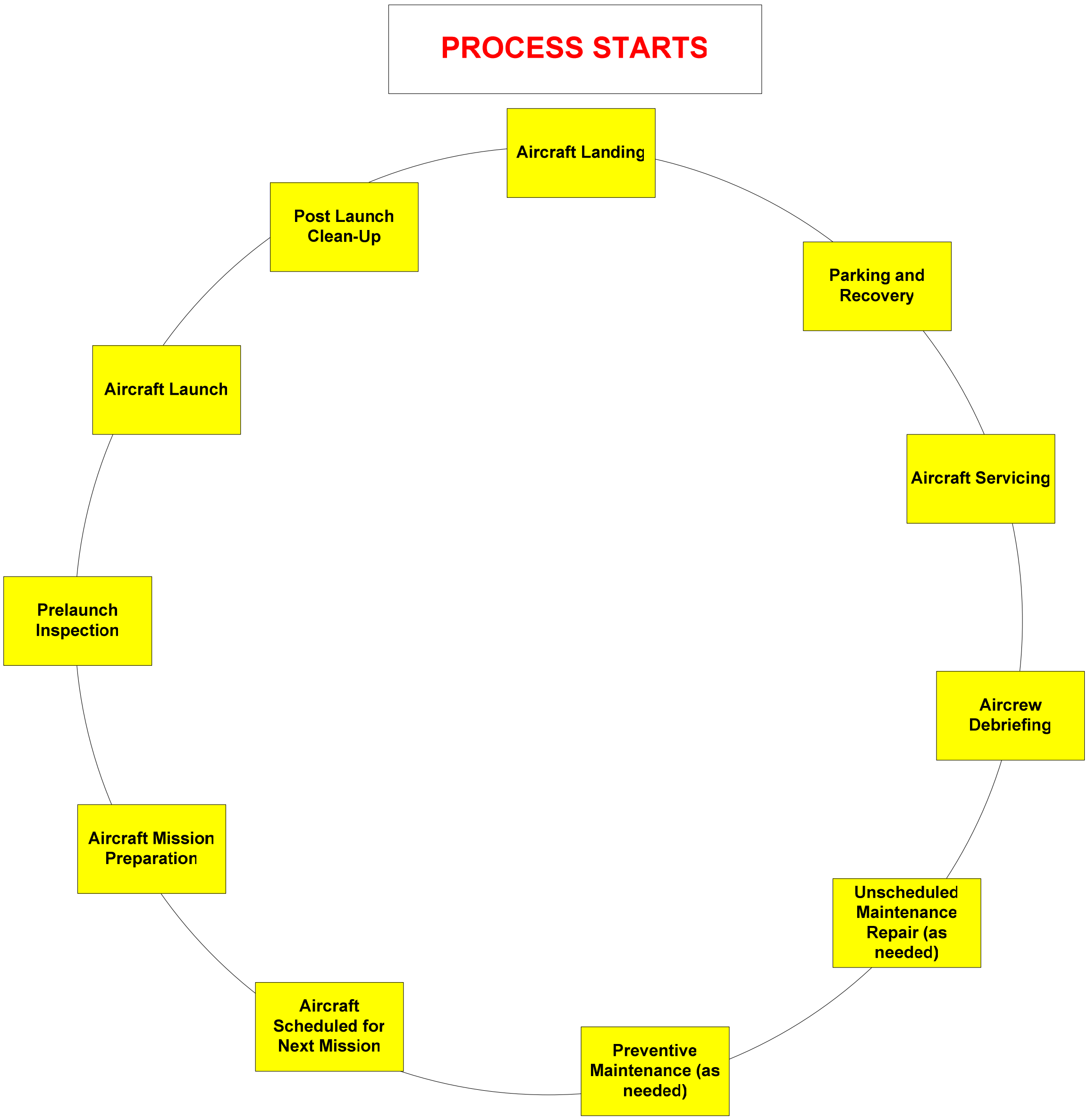


Figure 2. Flight Line Maintenance Process

The next steps in the flight line maintenance process prepare the aircraft for its next mission and may include weapons loading, software loading, and so on. With these steps completed, the aircraft is then ready for preflight inspections. The crew chief conducts the inspection and then the aircrew performs their inspection. The aircraft is

now ready to taxi to the end of the runway. F-16's require an end of runway inspection prior to aircraft take-off. Post-launch cleanup is then conducted to include the storing of fire extinguishers, inlet covers, chocks and so on.

AFI 21-101 ACC SUP 1 (ACC, 2002) supplements AFI 21-101 where specific details are provided concerning the sortie generation process for fighter aircraft. AFI 21-165 (ACC, 2003) implements AFI 21-101, establishes policy, and assigns responsibility for the operations group (OG), maintenance group (MXG), and mission support group (MSG) commanders to develop and execute aircraft flying and maintenance programs. This instruction allows units the flexibility to meet their mission requirement through effective flying and maintenance scheduling.

Hot Pit refueling is also accommodated in the conceptual model in Figure 1. In the case of surge or during training periods, jets can fly two consecutive sorties without shutting down the engine using a hot-pit. After landing, and if the jet can fly the next mission, a hot pit refueling takes place in a designated area. The aircraft is being refueled, quickly and carefully inspected (while the engine is running), and it takes off again without the need to perform parking, recovery, debriefing, mission preparation, and pre-launch inspections.

Based on the above information the conceptual model presented in Figure 1 was defined. This conceptual model is the foundation upon which the simulation model was built and validated (these concepts are discussed in Chapter III). The different scheduling philosophies studied in this research have the most impact in the red portion of the figure (AC Scheduling).

Maintenance Metrics

This part of the literature review (along with the Delphi study) helps to answer the second investigative question about defining the most appropriate measures concerning long term health of the fleet and maintenance effectiveness.

Air Force Logistics Management Agency (AFLMA) published a maintenance metrics handbook which is an encyclopedia of maintenance metrics. It includes an overview to metrics, a brief description of things to consider when analyzing fleet statistics, an explanation of data that can be used to perform analysis, a detailed description of each metric, and a formula to calculate the metric. It also includes an explanation of the metric's importance and relationship to other metrics (AFLMA, 2002). The handbook also identifies which metrics are leading indicators (predictive) and which are lagging indicators (historical). Appendix "A" lists some key metrics, provides a brief description of that metric with the desired trend, and presents some things to consider when a unit's performance is not meeting the desired trend. Appendix "B" describes metrics more in depth and provides the formulae to calculate the metrics that are used later in this research. The majority of this information also came from the maintenance metrics handbook (AFLMA, 2002).

The metrics handbook provides additional guidance on scheduling, work force management, sortie generation, and maintenance performance. The flying schedule sets the pace for the whole wing; and a flying schedule should attempt a smooth flow of resource use that includes people, aircraft, and consumables. In this research, the potential flying schedule was provided by Eielson AFB. However, a sensitivity analysis

was also performed by surging the schedule to identify potential problems in the sortie generation process.

The flying window, a block of time in the day in which flight operations are allowed to be conducted, drives shift scheduling, and the operations group and the maintenance group are not the only agencies involved in sortie generation. Fuels management, air traffic control, the weather squadron, and many others are also involved. Supervision for all activities must cover the entire flying window - and then some. The length of the flying window determines effectiveness of the maintenance fix shift; the less the flying window the more time can be allotted to fix shift for doing its job. For this research, the flying window is not established a-priori to negatively influence the scheduling philosophy, but it is computed as a dependent variable assuming that generally a shorter flying window is better (the work to be done can be done in shorter time and is not forced to be done in shorter time).

Re-configuring the aircraft during the day shift without an overwhelming need should be avoided. Operations and maintenance should work together to fly the same configuration for the entire week. Unnecessary aircraft re-configuration drains manpower from troubleshooting, repairing, inspecting, servicing, launching, and recovering. In this research, no re-configurations are simulated assuming that if they take place they don’t influence the sortie generation process. This assumption, along with some other assumed activities, produces lower resource utilization rates than the real ones.

Weekend duty should not be routine. Weekend duty should be based on rules, and aircraft should not be worked unless there is no other option but to work or replace a Monday flyer. For the purpose of this research, it is assumed that aircraft don’t fly and

maintenance does not work during the weekend. However, all the resources are simulated using the Arena® based "Ignore" scheduling rule, meaning that they will finish their task before leaving and that additional work time is seldom considered[4] (more details on this issue are given in Chapter IV).

In addition, a major issue identified in the 2001 Chief Of Staff Logistics Review (CLR) was sortie production and fleet health (Chief Of Staff Logistics Review, 2001). One of the objectives in this review was to balance management focus on sortie production and fleet health. For that reason, maintenance leaders and managers must understand and use metrics to drive a balance between daily sortie production goal and long-term fleet health. A comprehensive slide of this review illustrates the applicable maintenance metrics that drive overall balance, sortie production performance, and fleet health performance respectively (Figure 3).

In addition to CLR, Gray and Ranalli researched what methods had been employed in the past in selecting the aircraft maintenance performance factors to be examined (Gray & Ranalli, 1993). Selection methods ranged from using personal experience, expert opinions, and surveys. They provided a comprehensive list of variables and specified which ones were chosen as dependent and independent factors for each research effort. This list is enriched with more recent research (Allison, 1999; Beabout, 2003; Commenator, 2001; Faas, 2003) that deals with maintenance metrics. By aggregating the aircraft maintenance metrics used in this previous research, a useful observation of the most commonly chosen dependent performance factors may arise.

[4] A workers shift begins as scheduled regardless of how late they stayed during their previous shift.

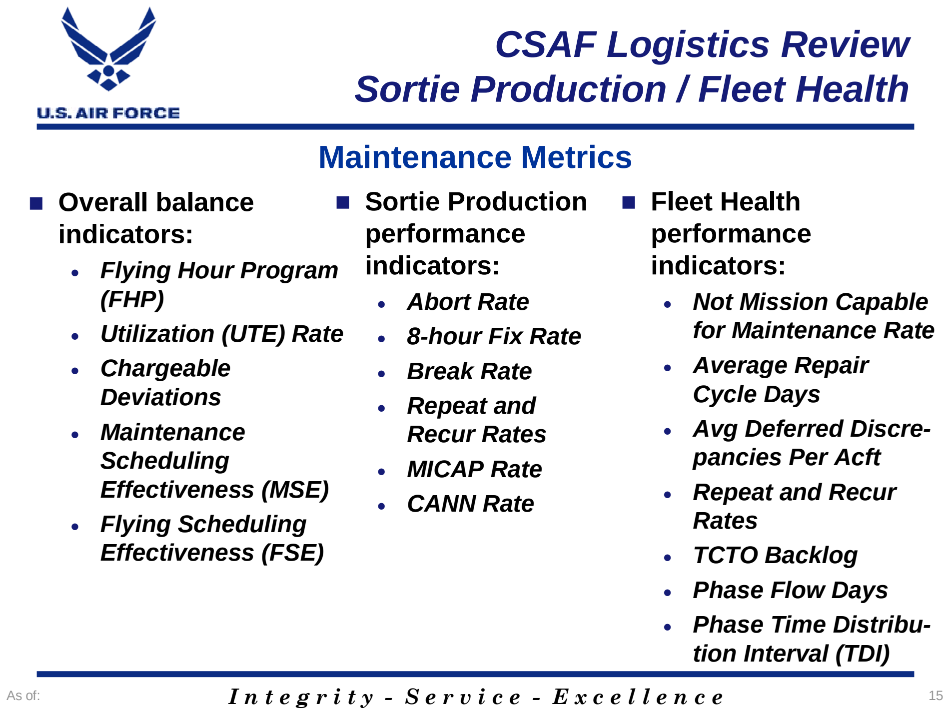


Figure 3. Metrics from CSAF Logistics Review

Other simulation studies of the sortie generation process

This section will highlight other simulation studies that have been conducted in the area of sortie generation. These simulation projects come from academia, small disadvantaged businesses, larger companies, and the government. The purpose of this section is to identify different simulation and programming techniques in order to enrich the simulation model built for this research with the most useful techniques.

Simulation of Autonomic Logistics System (ALS) Sortie Generation.

Faas modeled a sortie generation system in Arena® focusing on the impact of Autonomic Logistics System (ALS) in various measures of effectiveness (MOE) (Faas, 2003). As MOEs he used the Mission Capable Rate, Not-mission Capable for

Maintenance and Supply, and Flying Scheduling Effectiveness. He felt that these rates would offer the best way to observe the differences between the baseline system and the ALS, and also the differences between the various ALS levels that were set-up. He analyzed the impact of ALS to the MOEs by performing a full factorial design of experiments.

He utilized the advantage of named views in Arena and the associated hot keys to recall them. A graphical user interface (GUI) also allowed the user to change various parameters prior to each replication, and the route-station approach to move entities in the model was used. These techniques (the GUI, the hot key views, and the route-station approach) and the factorial design of experiments were also utilized in the model for this research.

LCOM.

LCOM (Logistics COmposite Model) is a Monte Carlo based, resource queuing, systems engineering tool (Defense Acquisitions University, 2001). It enables analysts to conduct capability assessments and trade-off studies on a variety of weapon systems within various scenarios. LCOM is sponsored by the Aeronautical Systems Center (ASC) and is currently in use by acquisition planning and program offices throughout the Department of Defense. LCOM was most recently validated and verified by ASC using F-15E Desert Storm data. LCOM databases are typically based on historical or engineering assessment data from systems such as Logistics Support Analysis (LSA), Maintenance Data Collection (MDC), Computer Aided Maintenance System (CAMS), Reliability and Maintainability Information System (REMIS), and Naval Aviation Logistics Data Analysis (NALDA), to name a few. Any number of data sources can be

used, with real, fictitious, or predicted data, but the data must be formatted to LCOM input requirements.

LCOM generates several categories of statistical output including Missions, Activities, Aircraft, Personnel, Shop Repair, Support Equipment and Facilities. In addition, any number of user-definable statistics can be created and reported on. Detailed reports on specific simulation activity can be generated for aircraft, missions, manpower, supporting resources, failure/task times, and depot workload/pipeline investment.

LCOM might be able to simulate some of scheduling philosophies of this research. However, because “LCOM users should expect to spend many months working with the model before they are able to lead a study or conduct a complex analysis” (Defense Acquisitions University, 2001) using it, it is not recommended for a thesis research.

SIMFORCE.

SIMFORCE (Scalable Integration Model for Objective Resource Capability Evaluations) is a desktop decision support tool that predicts resource utilization using simulation and modeling technology (Kelley Logistics Support Systems - KLSS, 2002). It calculates probable maintenance resource (people, equipment, vehicles, facilities, and parts) needs based on Air Force Wing operational taskings. SIMFORCE also determines the effects of reduced or increased levels of resources on sortie capability. The user can adjust operations tempo, taskings, resources and failure rates. The model captures the information on the logistics and maintenance operation and provides the output as spreadsheets and charts via Microsoft Excel™. Users familiar with Excel™ can use the raw data to create their own unique graphs to examine different views or answer different

questions. This feature (Arena® – Excel™ interaction) is quite interesting and was utilized in the model of this research.

LogSAM (Smiley, 1997).

The Logistics Simulation and Analysis Model (LogSAM™) is built by Synergy Inc. LogSAM™ also simulates the aircraft sortie generation process. The model is broken down into several modules: aircraft generation, sortie generation, preflight and launch, and post flight evaluation (a nice feature that will be utilized in this model using Arena's® routing and station approach). Added features include its ability to schedule sorties based on the Air Tasking Orders (ATO). These ATOs describe what targets to attack along with numbers and types of aircraft to use. Synergy has also expanded LogSAM™ to include a module called LogBase™. LogBase™ simulates enemy attacks and the effect those attacks have on sortie generation capability. Both LogSAM™ and LogBase™ are interesting applications but they are more applicable for a wartime simulation.

Simulation Model for Military Aircraft Maintenance and Availability.

The Helsinki University of Technology constructed a simulation model for the use of a fleet of Bae Hawk MK51 aircraft during their normal operational use (Raivio et al., 2001). The model describes the flight policy and the main factors of the maintenance, failure, and repair processes. The model aims at a better understanding of the critical paths in the normal service activity, and thus helps to determine ways to shorten the turnaround times in the maintenance process. Model implementation with graphical simulation software allows rapid what-if analysis for maintenance designers. Raivio (2001) then conducted sensitivity analysis with respect to the most important model

parameters, like the average duration of the maintenance operations and the manpower capacities of the repair facilities was carried out. The model was also built in Arena®.

Inferences – Advice from Other Simulation Models.

Based on the information provided above regarding the other simulation studies in the area of sortie generation process, the following useful hints were derived and were included in the model of this research:

1. Most of the simulation studies on sortie generation process were built in Arena®. Therefore, credibility can be given that Arena® provides a flexible simulation environment and is a very powerful tool.
2. Views and Hot Keys help in model verification.
3. Routing and station approach helps in model verification.
4. Graphical User Interface (GUI) allows the user to change various parameters prior to each replication, helping in conducting a Design of Experiments study.
5. Arena® – Excel™ interaction allows users to provide the output as spreadsheets and charts via Microsoft Excel™.
6. Sensitivity analysis gives insight for how a change in the parameters would affect the model output and information on the accuracy with which the input parameters have to be estimated.

Summary

Chapter II summarized the literature used to aid in determining the various scheduling philosophies and their impact to long term health of the fleet. The literature review included the following areas: the sortie generation process and the flexibility that

it provides to managers to apply different scheduling philosophies, the maintenance metrics that the USAF uses and how they are related to research question, and other simulation projects in the area of sortie generation. Chapter III describes the methodology and the data used to meet the research objective.

III. Methodology

Purpose Statement

The purpose of this research is to identify the most common aircraft scheduling philosophies, to identify the best metrics that capture the long term health of the fleet and maintenance effectiveness, and to assess whether there is statistical evidence that one of the philosophies is better (in terms of the metrics defined above) than the others and under what situations.

Research Paradigm

This research is a qualitative and quantitative hybrid analysis using:

1. The Delphi method to identify the most common aircraft scheduling philosophies
2. A combination of content analysis and the Delphi method to identify the applicable metrics that capture the long term health of the fleet and maintenance effectiveness, and
3. A sensitivity analysis and a designed experiment using factorial design to compare the simulation outputs of interest for different factors (i.e. scheduling philosophy, sorties goal, resource capacity, window between waves) and factor levels.

Methodology

Scheduling Philosophies (Question 1).

The commonly used F-16 unit scheduling philosophies that need to be compared in terms of improving the long term health of the fleet were identified by using sponsor's

(354 AMXS/CC, Eielson AFB) and personal experience, and by conducting a Delphi method sampling of expert beliefs on best maintenance scheduling philosophies of maintenance officers assigned at AFIT.

Delphi Technique.

The Delphi technique is a formalized process to determine the best answer or solution to a problem whenever insufficient or no applicable data exist. Basically, it is based on an iterative set of questionnaires that attempt to capture the thoughts and feelings of a group on a particular subject. At the end of each round, input obtained from the experts is averaged and the results broadcast back to the group. The same or new questions are then asked again, the results analyzed, and the conclusion modified. This cycle of questions, feedback, questions continue until the prediction stabilizes. The final conclusion is considered to be decision of the experts (Clayton, 1997).

The Delphi method can be considered a complement to the panel approach. However, unlike the panel approach, it provides more information regarding "uncertainties or disagreements about the subject and quantitatively evaluates the degree of uncertainty which exists within a large group of experts" (Linstone & Turrof, 2002: 217).

The main reason that the Delphi method was used is that expert responses eventually converge toward the most meaningful response through Delphi's consensus process. For this research, three web based questionnaires were conducted and consensus was achieved. Using the web based questionnaires decreased the non-response rate and helped with further analysis of the results (data were entered into an Excel file upon completion). Leedy's (Leedy & Ormrod, 2001: 202-209) recommendations for

constructing questionnaires and maximizing the response rate were followed. Below is a list of some of the recommendations that were followed and how they were implemented in this research:

1. Keep the questionnaire short. Questionnaires were as brief as possible and solicited only for information essential to the research question.
2. Word the questions in ways that do not give clues about preferred or more desirable responses. A careful approach was taken in wording the questions by checking for unwarranted assumptions implicit in the questions and trying not to influence the respondent's opinion.
3. Keep the respondents' task simple. The first questionnaire was asking for free text responses, which were quite time demanding but unavoidable because of the type of investigative questions (initial thoughts about maintenance philosophies and appropriate metrics). The next questionnaires were more straightforward and were asking for ranking initial responses (the second questionnaire) and agree or disagree with the responses (the last questionnaire).
4. Make the questionnaire attractive and professional looking. The questionnaires were web-based and were created by EN Web administrators using the Web Survey Information Retrieval System (WebSIRS). WebSIRS is an online tool that is used for the collection of survey data by the creators of student surveys. EN Web administrators, as professionals in the area of web-based applications, are the most appropriate to guarantee the professional looking and attractiveness of the questionnaires.

5. Conduct a pilot test. Questionnaires were initially installed in a test server where half a dozen individuals were asked to fill out the questionnaires to see whether they had difficulty understanding any items. The researcher was also able to see the kind of responses that would be answered down the road ensuring that the "real" responses would be of sufficient quality to help answer the research question.
6. Motivate potential respondents. Researcher gave people a reason to want to respond when he submitted the solicitation email message (Appendix "C"). He highlighted that with the respondents' help, their job might become easier and more effective, if the research goal (to identify the maintenance scheduling philosophy that "best" improves the long term health of the fleet and maintenance effectiveness to meet unit sortie production goal) was achieved.

A detailed description of the questionnaires follows after the following paragraph because Delphi technique was also used for partially answering the second investigative question.

Performance Metrics (Question 2).

The second investigative question needed some more archival research and was answered by critically assessing the results of a content analysis (described in next paragraph), the Delphi technique described previously and the proposal of the 2001 Chief of Staff Logistics Review (Figure 3). As a reminder, Appendix "A" lists some key metrics, provides a brief description of that metric with the desired trend, and presents some things to consider when a unit's performance is not meeting the desired trend.

Appendix “B” describes more in depth and provides the formulae to calculate the metrics that are used later in this research (AFLMA, 2002).

Content Analysis.

A content analysis is a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases (Leedy & Ormrod, 2001). Content analyses are typically performed on forms of human communication, including books, newspapers, films, television, art, music, videotapes of human interactions, and transcripts of conversation. For the purpose of this investigative question, former AFIT research related to aircraft maintenance was scrutinized to identify the most used metrics in the research efforts.

Gray and Ranalli (1993) provided a comprehensive list of variables used in previous research and specified which factors were chosen as dependent and independent for each research effort. This list was enriched with more recent research (Allison, 1999; Beabout, 2003; Commenator, 2001; Faas, 2003) that dealt with maintenance metrics. Due to the objectivity of the judgment (the list enrichment involved only the appearance of specific dependent or independent factor in the text of the recent research), only one judge (the researcher) was necessary. As a sample, all the post-1993, related to aircraft maintenance, theses was used.

One crucial step in a content analysis is to tabulate the frequencies of each characteristic found in the material being studied. Frequencies for each metric were reported, and the most frequently mentioned metrics were used for further analysis.

Delphi Technique Questionnaires.

Before the surveys were fielded and data were collected for the study, all the necessary approvals (HQ AFPC/DPSAS, 1996) were attained. These include the issuance of Survey Control Number by HQ AFPC/DPSAS and the approval for the use of volunteers in demonstrations by WPAFB Institutional Review Board. These approvals are presented in Appendices “D” and “E” respectively. Three questionnaires were conducted.

The first questionnaire (Appendix “F”) was seeking answers about:

1. The most commonly used scheduling philosophies that needed to be compared in terms of improving the long term health of the fleet and enabling maintenance managers to more effectively meet unit sortie production goals.
2. The important performance metrics that capture the long term health of the fleet and the maintenance effectiveness to meet unit sortie production goals.
3. Specific peace-time durations of various maintenance processes that would be used as model input variables.

The first two parts of the initial questionnaire were open ended and F-16 experience was not a prerequisite for answering them. On the other hand, only F-16 experienced maintenance managers were asked to respond to the third part (process durations) of the initial questionnaire. Due to limited number of the sample size, the responses to the third part were useless to the study and all the process durations were given by Eielson AFB experts (see Chapter 4).

After parsing the initial responses, a second survey (Appendix “G”) was conducted seeking answers about:

1. Which scheduling philosophies, identified in initial round, were more important.
2. Which metrics, identified in first round, that capture the long term health of the fleet, were more important.
3. Which metrics, identified in first round, that capture the maintenance effectiveness to meet unit sortie production goals, were more important.

Respondents were asked to rank only their top-10 selection (in order of preference from 1 to 10, where 10 denoted the most significant) and provide their rationale for their decision. This ranking was preferred instead of grading all the initial responses because respondents were "forced" to completely disregard the less significant (not in the top-10) initial responses, giving as a result to the researcher not only the most significant responses but the most useless also.

After parsing the responses of the second survey, a third survey (Appendix "H") was conducted presenting the results to the respondents and requesting their consensus. Three point estimates were used to illustrate the ranking of the responses; the mean (the sum of rankings divided by the number of responses), the median (the middle number when the grades are arranged in ascending order), and the mode (the ranking order that occurred most frequently in the responses). A higher mean for a response denotes that many of the respondents selected the specific response in their top list and usually in their top-5. Higher median denotes that most of the respondents selected the corresponding response in their top-10 list. Mode is usually zero because all the unselected in top-10 responses were automatically assigned zero-grade (zero was used as an indication of lack of importance). If it is not zero, it denotes what is the opinion of most of the respondents

regarding the corresponding response. All these estimates will be mentioned again and critically evaluated in chapter IV.

Collection and Analysis (Questions 3 and 4).

This is the most quantitative part of the research. Once the philosophies and the performance measures had been identified, a stochastic simulation model was built (in Arena® 7.1) to simulate the different philosophies. In order to answer the third investigative question, sensitivity analysis was performed for various levels of manning, sortie schedule, duration between landing and consecutive take-off, and daily schedule uniformity to identify any potential bottlenecks in the sortie production process. The sensitivity analysis results helped in identifying the most influential factors that affect the metrics that capture the long term health of the fleet and maintenance effectiveness. In order to answer the fourth investigative question, a Design of Experiments (DOE) factorial design approach was used to assess if statistically significant differences exist between the most influential factors identified by the sensitivity analysis. In the following paragraphs the simulation model, the data analysis portion of it, the sensitivity analysis and the factorial design approach are presented.

Simulation Model.

The steps that composed the simulation study are depicted in Figure 4 (Law & Kelton, 2000). Each one of these steps and the way they were implemented for this research is analyzed below:

1. Formulate the problem and plan the study

   The overall objectives of the study and the specific questions to be answered by the study were presented in Chapter I. During this step, the performance

measures that will be used to evaluate the efficacy of different system configurations need to be addressed. For the purpose of this research the performance measures were addressed by answering the second investigative question.

2. Collect data and define the model

   Data should be collected to specify model parameters and input probability distributions. Eielson AFB provided raw data and their estimation of various durations during the sortie generation process. Details on how the input probability distributions were defined are provided later in this chapter. The conceptual model was defined by the literature review and was presented in paragraph 2.2 (Figure 2).

3. Is the conceptual model valid?

   A structured walk-through of the conceptual model was performed before an audience of Subject Matter Experts (SMEs). This took place before programming begun to avoid significant reprogramming later. More on validation of the model will be provided later in the chapter.

4. Construct a computer program and verify

   The model was programmed in simulation software (Arena® 7.1) and some parts of it in Visual Basic for Applications (VBA®). The program was verified (debugged) using common programming debug practices and some unique to simulation programs. More on verification of the computer program will be provided later in the chapter.

5. Make pilot runs

These pilot runs were used for the next step (validating the model).

6. Program model valid?

   The model outputs were compared with common sense initially and with the real system afterwards. Two SMEs reviewed the model results for correctness and sensitivity analysis was performed to determine what model factors had a significant impact on performance measures and, thus, had to be modeled carefully.

7. Design of experiments

   The length of each run, the length of the warm-up period and the number of independent simulation runs using different random numbers were specified (see Chapter IV).

8. Make production turns

   Production runs were generated and they created output data for the next step

9. Analyze output data

   Analysis of data output had two major objectives:

   a. To determine the absolute performance of certain system configurations (answering third investigative question).
   b. To compare alternative system configurations in a relative sense (answering fourth investigative question).

10. Document, present, and use results

    This is actually the purpose of this thesis; to document the assumptions, the computer program, and study's results for use in the current and future research.

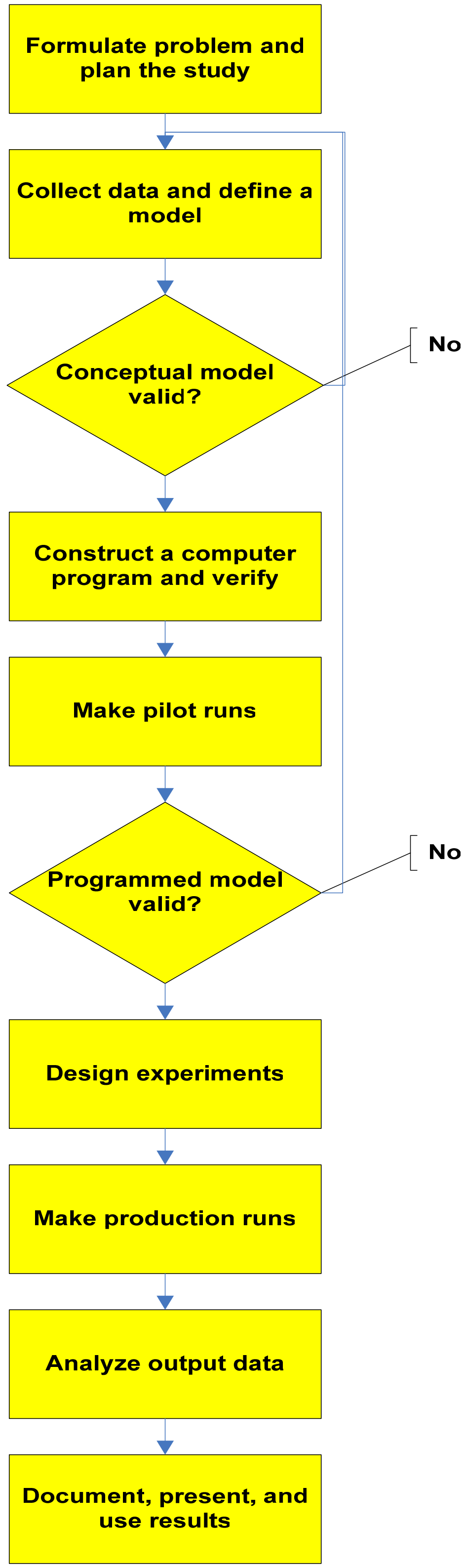


Figure 4. Steps in the Simulation Study

Model Introduction.

The first items to be described are the different views of functional areas setup in the model. Taking advantage of the named views in Arena, several of these views were established for ease of navigation. Table 1 shows these functional areas and provides the associated hot key used to recall that view. The model is setup with Arena's stations and routings approach so that white space exists between the different areas that were simulated. These station and routing modules move the aircraft entities between the appropriate areas. The white space also is preferable to make the model easier to understand and debug. The model was built in logical "subroutines" and debugged before combining with other "subroutines". Verification and validation took place in each subroutines combination process to ensure that the subroutine interact with each other in the intended way. All different options (maintenance philosophies) that were compared for this research were modeled using the same model based on a parameter set "entered" before the simulation run was started (the setting of one variable in the graphical user interface defines that option). The graphical user interface is described in the next paragraph.

Table 1. Model Views

View	Hot Key
Mission preparation	(m)
Phase	(p)
Scheduling	(c)
Check Failure	(f)
Statistics	(s)
Taxi – Takeoff – Fly – Land	(t)
Unscheduled Mx	(u)

This model is made up of a collection of process delays with fluctuating resource availability, decision modules, routing stations setup, and VBA code to simulate the baseline sortie generation process described in the conceptual model (Figure 1). The process delay times were defined by analyzing historical data from Eielson AFB, by in-depth discussion with two subject matter experts, and by input from experienced personnel from Eielson AFB including the sponsor of this study (354 AMXS/CC). Table 2 shows these processes and failure rates, associated times with the processes, the various resources schedule, and how these values were calculated.

Table 2. Variables – Processes Values

Variable – Process	**Value**	**Defined by**
varGroundAbortFailure	4.83%	Analyzing 1 year data from Eielson AFB
varAirAbortRate	0.26%	Analyzing 1 year data from Eielson AFB
varAfterFlightFailureRate	50.51%	Analyzing 1 year data from Eielson AFB
varHrsBetwWaves	Input on VBA Form	User – used for sensitivity analysis
varJanSorties	345	User in VBA form – used for sensitivity analysis
varDecSorties	330	-//-
varNovSorties	330	-//-
varFebSorties	340	-//-
varOctSorties	370	-//-
varJunSorties	480	-//-
varSepSorties	290	-//-
varMaySorties	410	-//-
varAugSorties	440	-//-
varJulSorties	370	-//-
varMarSorties	420	-//
varAprSorties	345	-//-
varPercentSurge	Input on VBA form	User – used for sensitivity analysis. Percent by which the monthly schedule is increased to simulate surge periods.

Table 2. - continued

vardays_prior	2 hours – input on VBA form	Day-shift personnel report 2 hours prior to the first launch in accordance with Eielson AFB input. It can be changed to reflect base needs.
varmids_prior	8 hours – input on VBA form	Mid-shift personnel report 8 hours prior to the first launch in accordance with Eielson AFB input. It can be changed to reflect base needs.
varswings_after	6 hours – input on VBA form	Swing-shift personnel report 6 hours after the first launch in accordance with Eielson AFB input. It can be changed to reflect base needs.
varapg_days	17 – input on VBA form	Average manpower for days APG in accordance with Eielson AFB input.
varapg_mids	4 – input on VBA form	Average manpower for mid-shift APG in accordance with Eielson AFB input.
varapg_swings	10 – input on VBA form	Average manpower for swing-shift APG in accordance with Eielson AFB input.
varavionics_days	11 – input on VBA form	Average manpower for day-shift Avionics in accordance with Eielson AFB input.
varavionics_mids	0 – input on VBA form	Average manpower for mid-shift Avionics in accordance with Eielson AFB input.
varavionics_swings	10 – input on VBA form	Average manpower for swing-shift Avionics in accordance with Eielson AFB input.
vareande_days	4 – input on VBA form	Average manpower for day-shift Electrical and Environmental (E&E) in accordance with Eielson AFB input.
vareande_mids	0 – input on VBA form	Average manpower for mid-shift E&E in accordance with Eielson AFB input.
vareande_swings	3 – input on VBA form	Average manpower for swing-shift E&E in accordance with Eielson AFB input.

Table 2. – continued

varengine_days	2 – input on VBA form	Average manpower for day-shift Engine in accordance with Eielson AFB input.
varengine_mids	0 – input on VBA form	Average manpower for mid-shift Engine in accordance with Eielson AFB input.
varengine_swings	3 – input on VBA form	Average manpower for swing-shift Engine in accordance with Eielson AFB input.
varweapons_days	25 – input on VBA form	Average manpower for day-shift Weapons in accordance with Eielson AFB input.
varweapons_mids	7 – input on VBA form	Average manpower for mid-shift Weapons in accordance with Eielson AFB input.
varweapons_swings	20 – input on VBA form	Average manpower for swing-shift Weapons in accordance with Eielson AFB input.
varduration_mids	6 – duration for which only mids shift is present	varmids_prior – vardays_prior
varduration_midsdays	4 – duration for which mids and days shifts are present	varworking_goal – varmids_prior + vardays_prior[5]
varduration_days	4 – duration for which only days shift is present	varswings_after + varmids_prior – varworking_goal[6]

[5] The calculation is derived as follows: varduration_midsdays = (Time that mids leave) – (Time that days show up) = (Schedule_start – varmids_prior + varworking_goal) – (Schedule_start – vardays_prior) = varworking_goal – varmids_prior + vardays_prior = 10 – 8 + 2 = 4 (independent from schedule start)
[6] The calculation is derived as follows: varduration_days = (Time that swings show up) – (Time that mids leave) = (Schedule_start + varswings_after) – (Schedule_start – varmids_prior + varworking_goal) = varswings_after + varmids_prior - varworking_goal = 6 + 8 - 10 = 4 (independent from schedule start)

Table 2. - continued

varduration_daysswings	2 – duration for which days and swings shifts are present	varworking_goal – vardays_prior – varswings_after[7]
varduration_swings	8 – duration for which only swings shift is present	24 – varmids_prior – varworking_goal + vardays_prior[8]
varAfterFlightHotPitFailureRate	25%	It is believed that half of the failures (varAfterFlightFailureRate / 2) permit next mission execution. Pilots may leave these failures unrecorded for flying the next mission after hot pit. These failures don't affect flight safety and are reported after the consecutive sortie.
varunbalanced	20% -- input on VBA form	In unbalanced approach the number of aircraft per wave is calculated by increasing or decreasing the normal number of aircraft by this percentage. Eventually the same sorties are scheduled but in an unbalanced way.
TakeOff	TRIA(2, 3, 4)[9]	It takes usually 2 to 4 minutes to takeoff. No impact to the model
Fly Sortie	MX(.5, NORM(1.3,.2))	Truncated (> .5 values) normal distribution with mean 1.3 and standard deviation 0.2 in accordance with Eielson's input.

[7] The calculation is derived as follows: varduration_daysswings = (Time that days leave) – (Time that swings show up) = (Schedule_start - vardays_prior + varworking_goal) – (Schedule_start + varswings_after) = varworking_goal - vardays_prior - varswings_after = 10 – 2 - 6 = 2 (independent from schedule start)

[8] The calculation is derived as follows: varduration_swings = (Time that mids show up next day) – (Time that days leave) = (24 + Schedule_start - varmids_prior) – (Schedule_start - vardays_prior + varworking_goal) = 24 - varworking_goal - varmids_prior + vardays_prior = 24 - 10 – 8 + 2 = 8 (independent from schedule start)

[9] Triangular distributions were used because there were no raw data available; only the minimum, maximum and most likely values were available by Eielson's AFB subject matter experts (Law & Kelton, 2000).

Table 2. - continued

Land	TRIA(2, 3, 4)	In accordance with Eielson's AFB input
Park and Recovery	TRIA(5, 7, 9)	In accordance with Eielson's AFB input
Phase Mx	TRIA(7, 7, 8) (days)	In accordance with Eielson's AFB input
SignOff Discrepancy and Document EandE	TRIA(10, 20, 30)	In accordance with Eielson's AFB input
Taxi	TRIA(8, 9, 10)	In accordance with Eielson's AFB input
Launch	TRIA(30, 37, 45)	In accordance with Eielson's AFB input
EOR after land CC	TRIA(4, 5, 6)	In accordance with Eielson's AFB input
EOR check CC	TRIA(6, 8, 9)	In accordance with Eielson's AFB input
EOR check Weapons	TRIA(6, 8, 9)	In accordance with Eielson's AFB input
EOR after land Weapons	TRIA(5, 7, 10)	In accordance with Eielson's AFB input
Pilot Preflight	TRIA(8, 12, 14)	In accordance with Eielson's AFB input
Hot Pit	TRIA(8, 10, 12)	In accordance with Eielson's AFB input
Mission Preparation Refuel	TRIA(20, 22, 25)	In accordance with Eielson's AFB input
Mission Preparation Weapons	TRIA(45, 60, 78)	In accordance with Eielson's AFB input
AvionicsFailure	See Appendix "I" for complete description	Arena's® Input analyzer – analyze 1 year failure data from Eielson AFB
WeaponsFailure	See Appendix "I" for complete description	Arena's® Input analyzer – analyze 1 year failure data from Eielson AFB
EngineFailure	See Appendix "I" for complete description	Arena's® Input analyzer – analyze 1 year failure data from Eielson AFB

Table 2. - continued

EandEFailure	See Appendix "I" for complete description	Arena's® Input analyzer – analyze 1 year failure data from Eielson AFB
APGFailure	See Appendix "I" for complete description	Arena's® Input analyzer – analyze 1 year failure data from Eielson AFB
SignOff Discrepancy and Document Engine	TRIA(10, 20, 30)	In accordance with Eielson's AFB input
SignOff Discrepancy and Document Weapons	TRIA(10, 20, 30)	In accordance with Eielson's AFB input
SignOff Discrepancy and Document Avionics	TRIA(10, 20, 30)	In accordance with Eielson's AFB input
SignOff Discrepancy and Document APG	TRIA(10, 20, 30)	In accordance with Eielson's AFB input

VBA.

There are three big portions of VBA programming in the model: the graphical user interface, the calculation of number of aircraft per wave, and the collection of statistics in Excel. A graphical user interface (Figures 5 and 6) was built to allow the user to change the main parameters between each replication. It consists of one main form, where the maintenance philosophy to be checked is selected, and two sub-forms, where the potential monthly flying schedule and the maintenance personnel can be entered.

The user interface and the parameter sets that are "passed" to the Arena simulation model provide tremendous benefits to this research:

1. They help with model verification because only one model needs to be constructed and verified. All the different maintenance scheduling philosophies, resources, flying schedules, hours between waves can be incorporated into the same model based on each replication's parameter set.

2. They help in the designed experiment approach because the factors of the design can be altered in each replication while all other things can be hold constant.
3. They help in sensitivity analysis of various factors by using a percent (increase or decrease) parameter for these factors which is editable for each replication.
4. They help in enhancing external validity of the model because all the parameters can be edited by the user to accommodate other bases or other type of jets.

In order to calculate the number of aircraft per wave, the desired flights per month has to be entered manually in the VBA form. Several functions were built to determine the flying days per month, and the waves per month and per day, depending upon the maintenance philosophy that was selected through the graphical user interface. The collection of statistics in Excel is “fired” with a VBA module every (simulated) midnight. The Excel file is created at the start and saved at the end of simulation. A complete listing of the VBA code is provided in Appendix “J”.

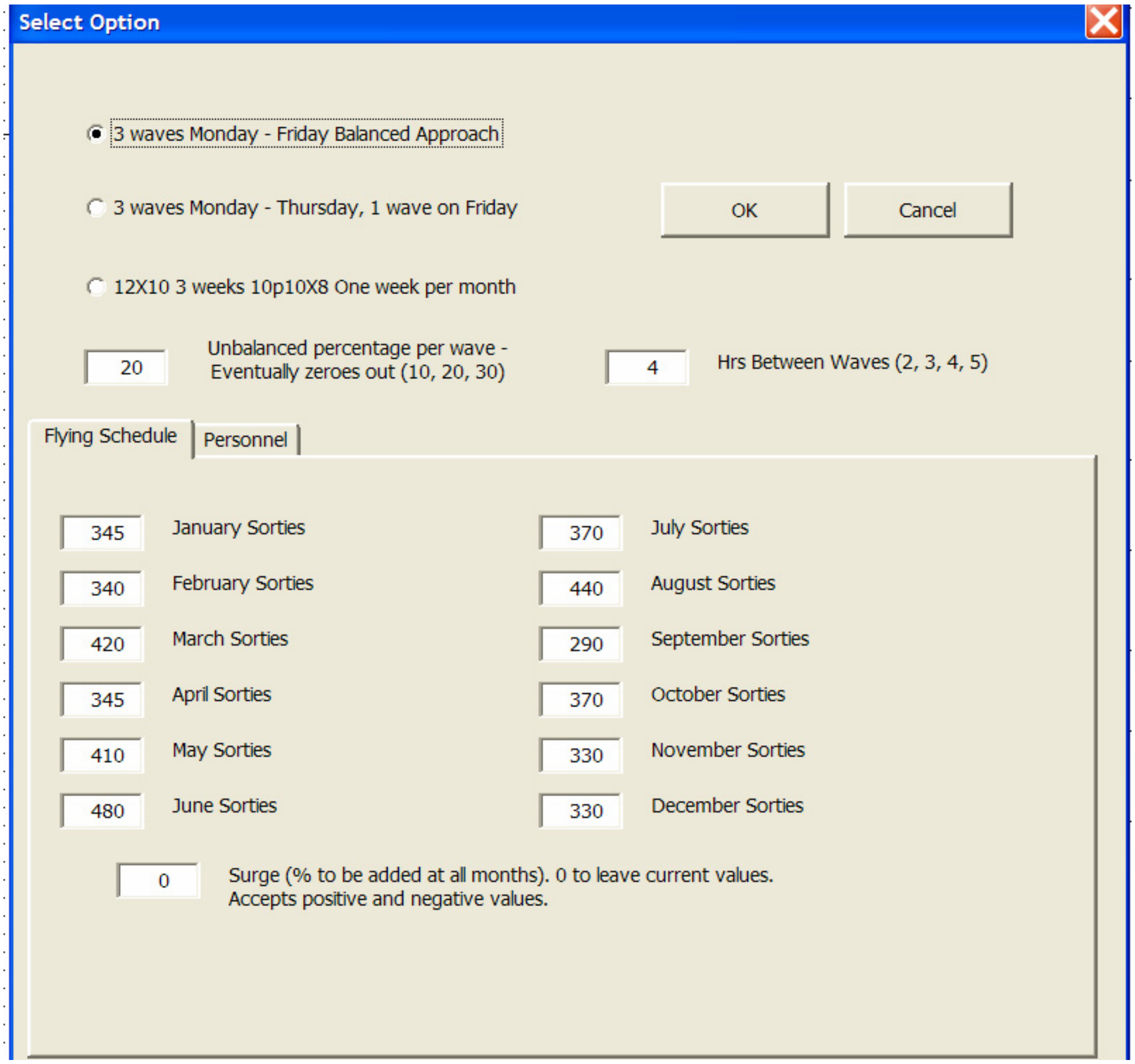


Figure 5. Graphical User Interface 1st Page

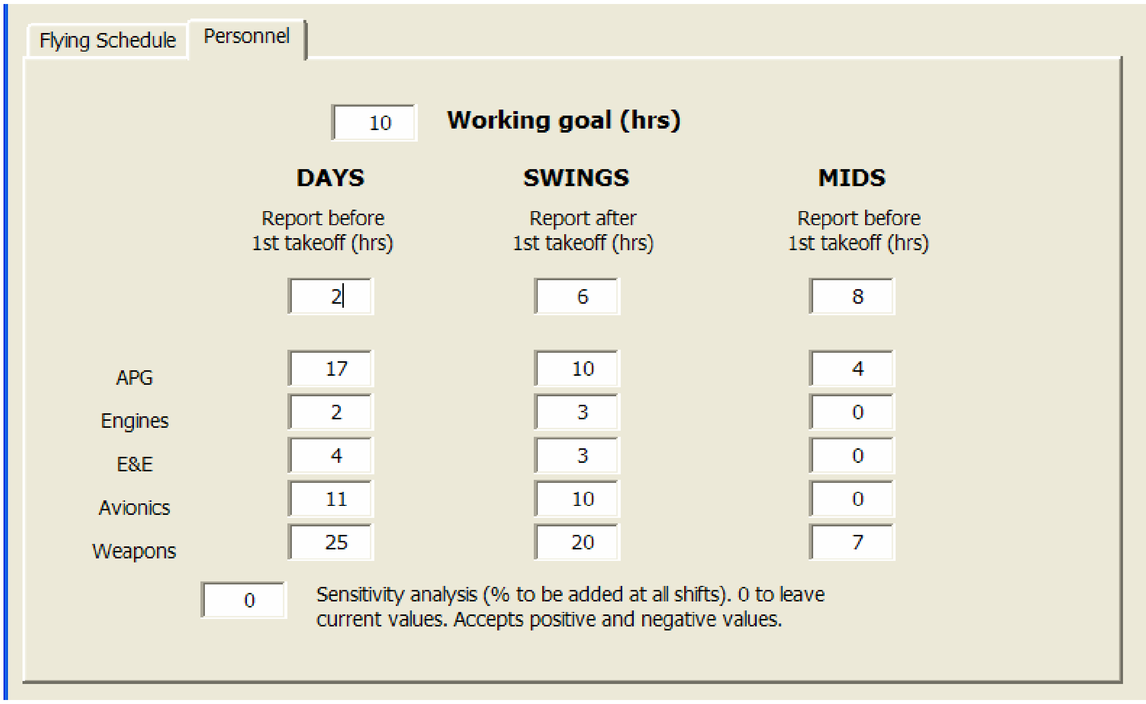


Figure 6. Graphical User Interface 2nd Page

Create Area.

The 18 aircraft entities (in accordance with Eielson's AFB input) are created once and never leave the system (Figure 7). However, the entities are not running continuously in the model but they are held at various positions (to form a wave, to become working day, and to start a new day – which is simulated to start at 08:00). After initial creation, the aircraft are assigned times since last phase inspection with a random draw from the uniform UNIF(0,300) distribution. This will prevent all aircraft from entering phase maintenance at the same time. The aircraft entities are also assigned additional information to include: the upcoming sortie is not their last sortie (to control which inspection to perform - thruflight or combined basic post-flight and preflight), and the

aircraft will be routinely inspected (not hot-pit) (Figure 8). After the “create area” and assigning initial attributes the jets are routed to the “check for failures” area.

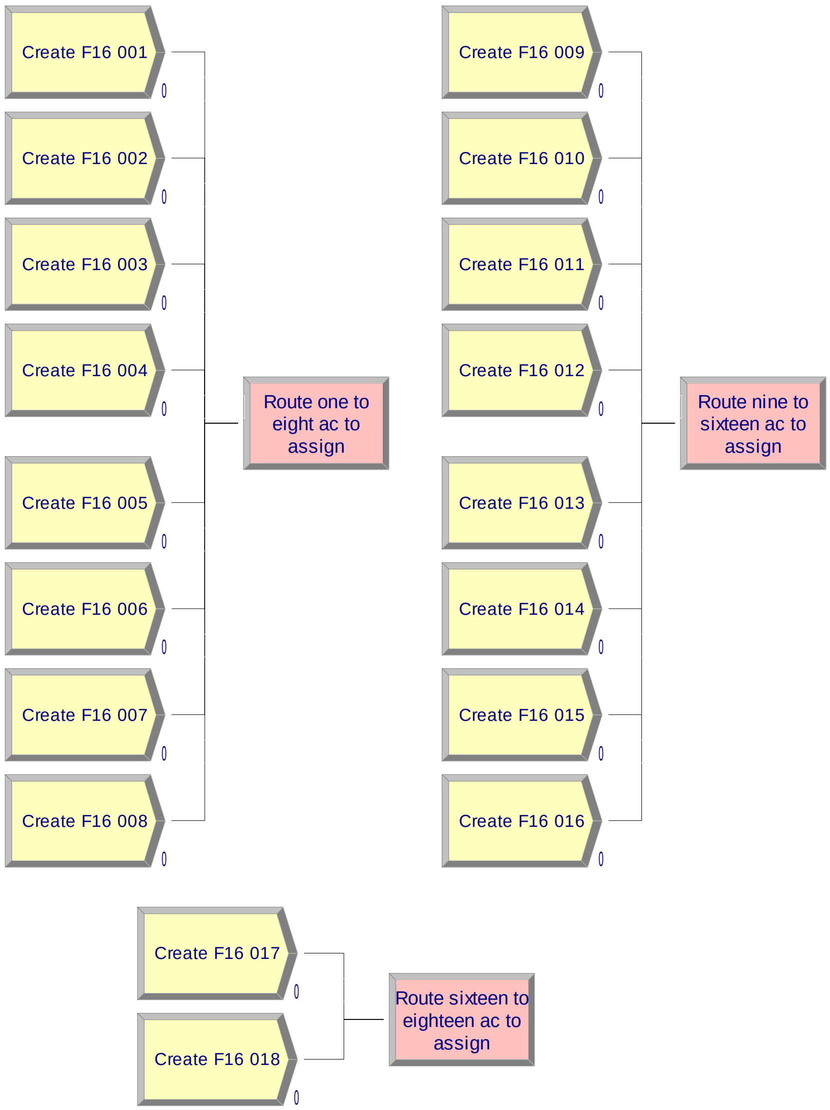


Figure 7. Create Area

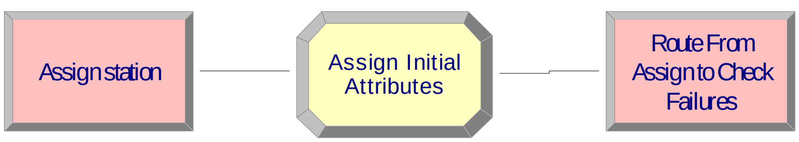


Figure 8. Assign after Creation Area

Check for Failures Area.

A decision is made if the aircraft has a failure based on the percentages presented in Table 2 and analyzed in Appendix "I". Attributes are passed to each jet regarding which Primary Working Center (PWC) will work on the failure and how long will it take to bring back the jet in operational status. Entities are routed either to "Unscheduled Maintenance Failure" Area (if there is a failure) or to "Check for Scheduled Maintenance" Area (if there is not) (Figure 9).

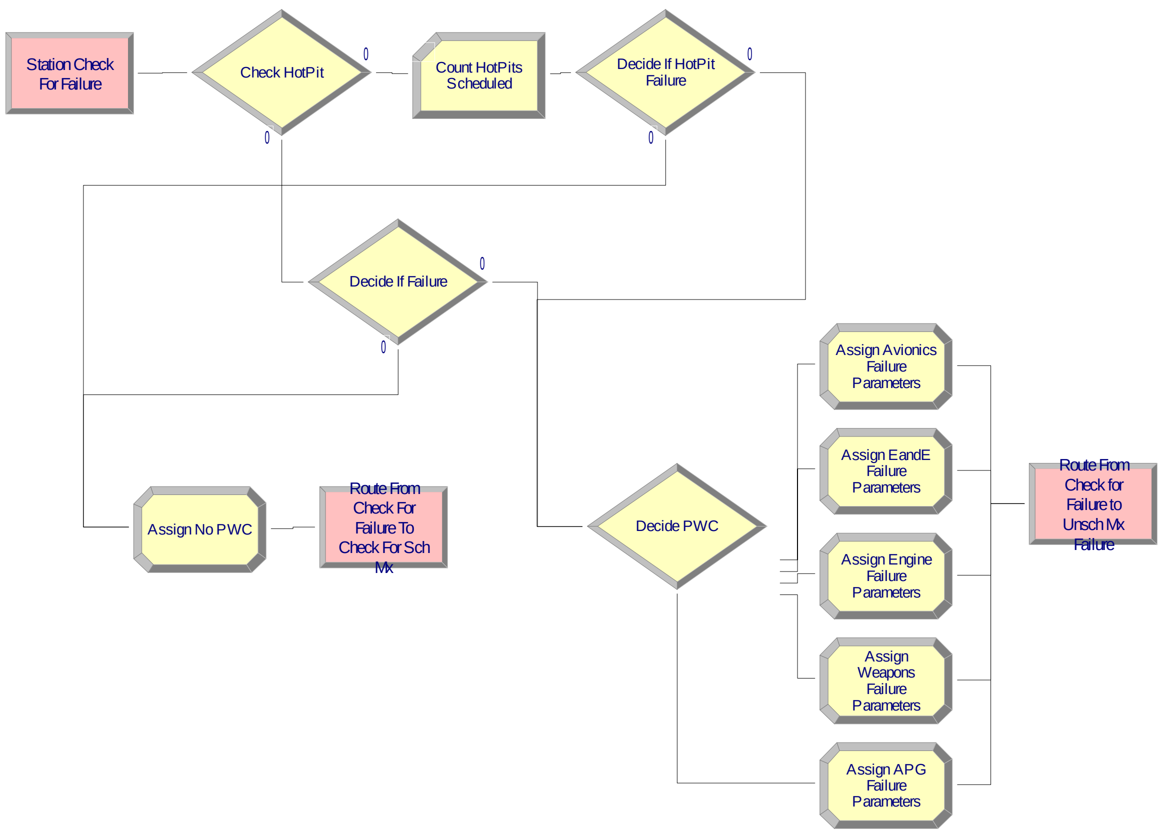


Figure 9. Check for Failures Area

Unscheduled Maintenance Failure Area.

This is the area where all the failures are taken care of (Figure 10). If more than one failure is in the queue to be worked from a specific PWC then the failure with the lowest duration is selected from the queue (not a First In First Out rule). This simulates the real world better where everyone's goal is to finish with easy failures first, providing (faster) more available jets to squadron's leadership. When the failure requires cannibalizing another jet for a spare part, the repair times are doubled to illustrate the extra work. After the PWCs sign off the discrepancies, times to repair are captured for later use at the statistics collection area, and the entities are routed to "Check for Scheduled Maintenance" Area.

Check for Scheduled Maintenance Area.

If scheduled maintenance is required (aircraft reached 300 flying hours since their previous phased inspection) then the entities are routed to the "Phase Area". Otherwise, if the jets need to be routinely inspected they are routed to "Parking Area" (where the inspection will take place), and if they have to be hot-pit refueled only, they are routed to "Hold Area" (where the waves are formed and various decisions are made, depending on the applicable maintenance scheduling philosophy) (Figure 11).

Phase Area.

In the "phase area" (fig. 12) the jets perform the scheduled phased inspection and the durations of these inspections are captured to determine the MC Rates at the statistics area. The captured durations are explained in the "statistics collection area" paragraph below. It is assumed that the phase maintenance technicians are available when needed.

These are different technicians from those that belong to the sortie generation system. After the end of the phase inspection the jets are routed to the “Hold Area”.

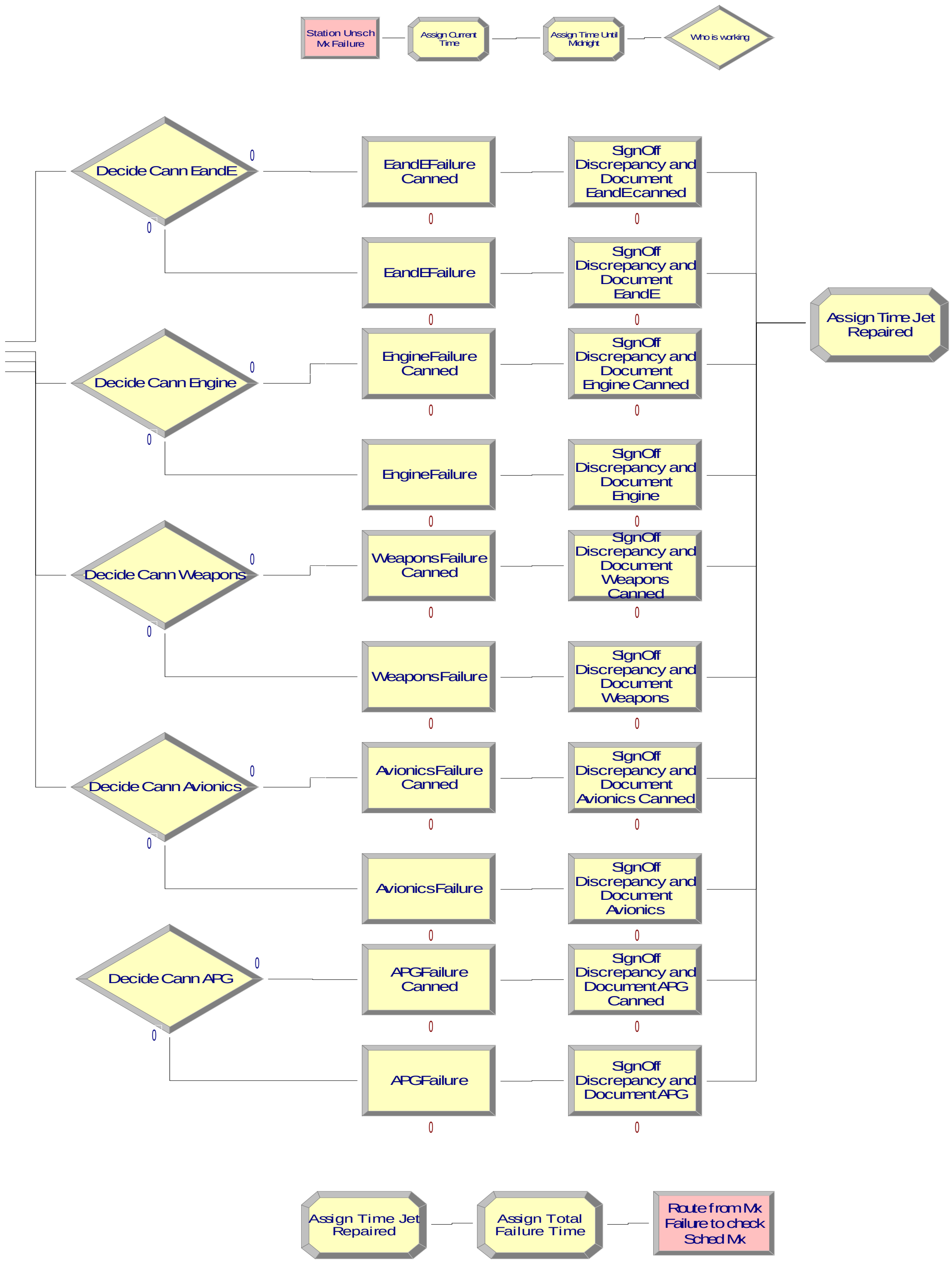


Figure 10. Unscheduled Maintenance Failure Area

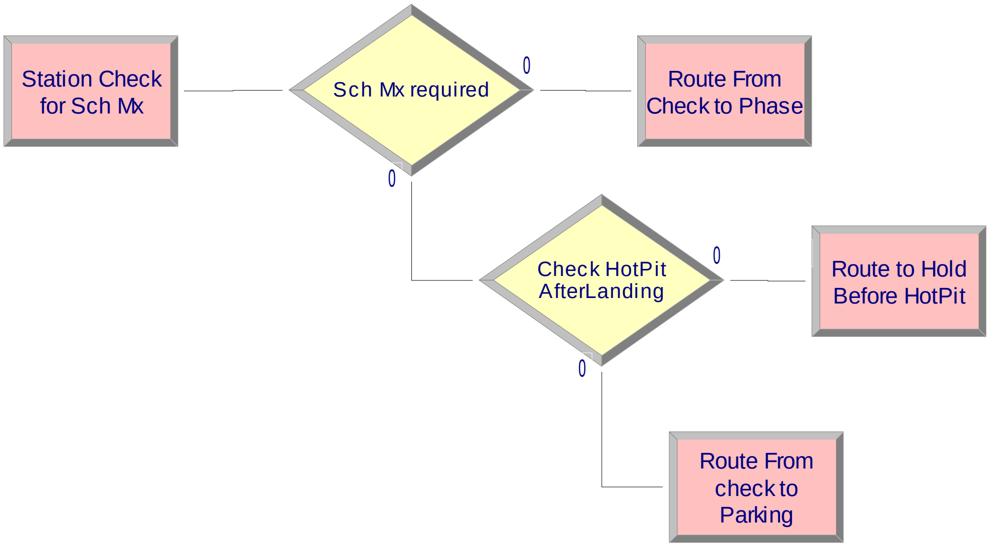


Figure 11. Check for Scheduled Maintenance Area

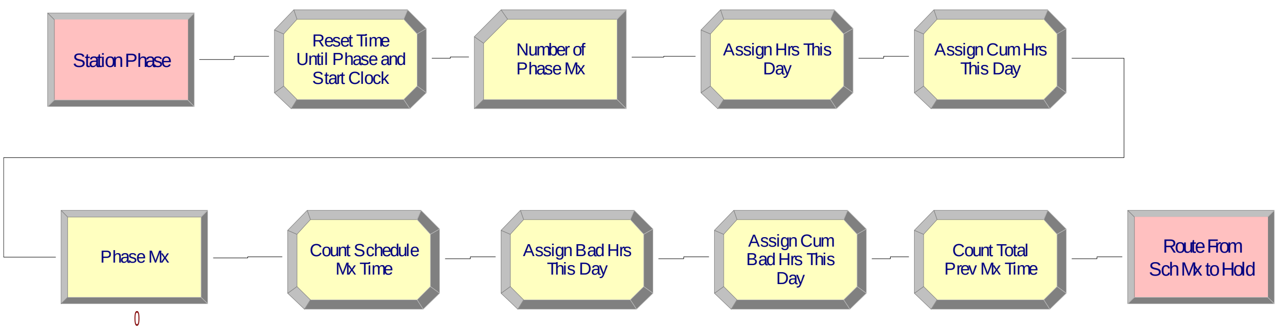


Figure 12. Phase Area

Parking Area.

In the parking area, the jets are parked and the engines are shut down. Appropriate safety pins are installed and the entities can be routed to “Mission Preparation Area” where the inspection and pilot debriefing are taking place.

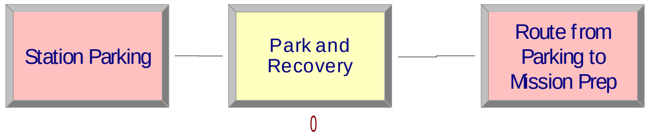


Figure 13. Parking Area

Mission Preparation Area.

If the last sortie of the day for the specific jet was flown, then a combined Basic Post-Flight / Preflight Inspection needs to be performed, otherwise a thruflight inspection is sufficient (Figure 14). Both servicing and debriefing run simultaneously; whichever process is shorter is processed first and then the remainder of the time is processed in the second delay module. Figure 15 shows the split depending on the duration of the servicing and debriefing processes. The current process times do not require this decision area since the maximum debrief time is less than the minimum service time, but the logic is included in case there was a change to the times (Faas, 2003). The aircraft are then refueled and loaded with the applicable weapons and routed to the "Hold Area" (Figure 16).

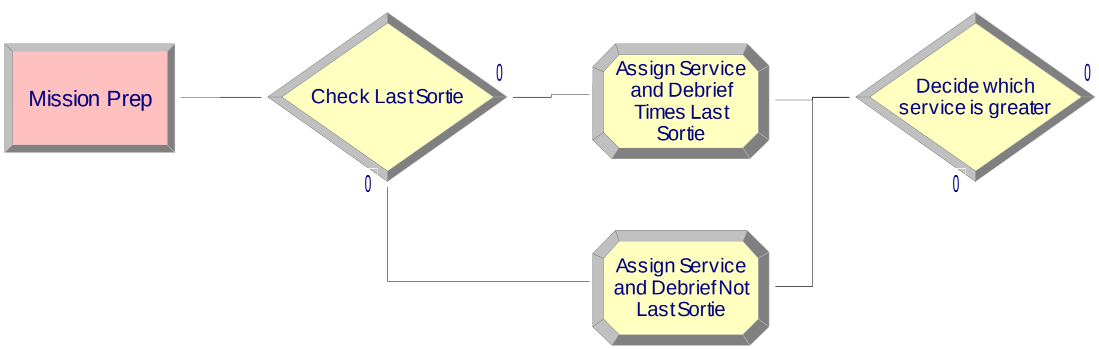


Figure 14. Assign Service Times Based on Last Sortie

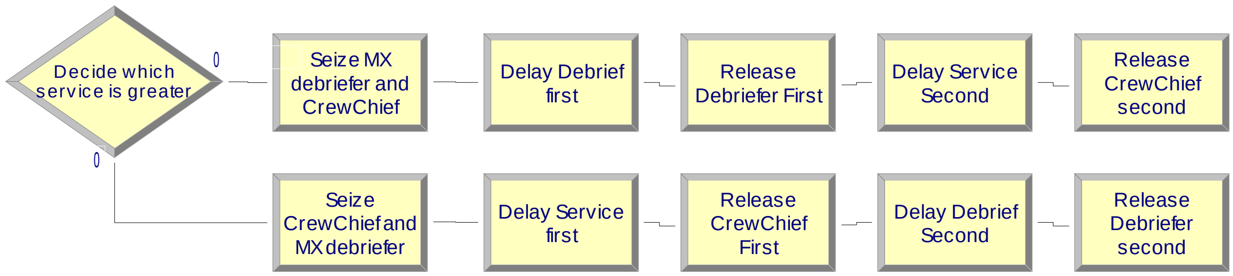


Figure 15. Concurrent Run of Service and Debrief

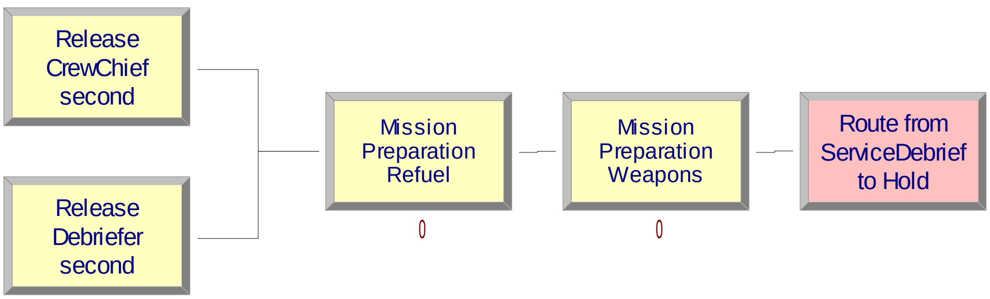


Figure 16. Refueling and Weapons Preparation

Hold Area.

This area and the statistics area are the most important for answering the third and fourth investigative questions because the "Hold Area" describes the scheduling procedure of the conceptual model (Figure 2) and the "Statistics Area" captures the influence of the maintenance philosophy in the appropriate metrics. Once the maintenance scheduling philosophy is selected through the graphical user interface (Figure 5), a decision module (Figure 17) routes the entities to the proper modules where the variables and attributes are altered based on the selected philosophy (Figure 18). The option to check in Figure 17 corresponds to the pre-selected maintenance scheduling philosophy from the graphical user interface. For example, if the maintenance scheduling philosophy is "flying 3 waves from Monday to Thursday and one wave on Friday", the

entities are routed to the appropriate decision module to check the current simulation day (mainly if it is Friday or not) and then to appropriate assign module to assign the waves allowed for the specific day.

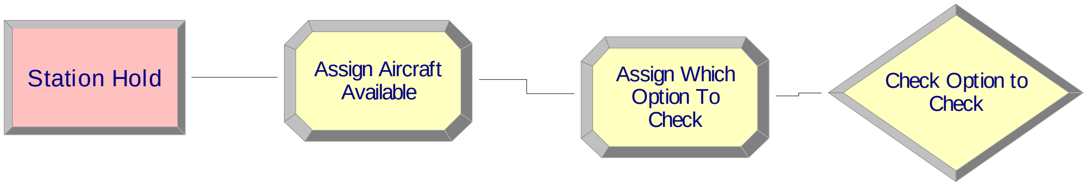


Figure 17. Hold Area (1 out of 5)

A hold module (Figure 19) holds the jets if it is (simulated) weekend (no flights during weekends), if the current wave is greater than the wave allowed (the schedule has already been met), and if the time between waves is less than the predefined hours between waves from the graphical user interface. The jets are hold until all the holding conditions change. Then the waves are formed (performed by a batch module with an appropriate batch size - computed in VBA) and then the jets are again separated (Figure 20), keeping their initial attributes, to be routed to the “mission preparation area”.

If the next mission is to be hot-pit refueled, then the jets are routed to a designated “Hot Pit Area”, otherwise they are routed to the “Pilot Preflight Area” (Figure 21). This Hold Area can be thought as a decision process that happens anytime the jets need to be scheduled to fly. For example, if the jets are hot-pit refueled, they are routed through the “Hold Area” after the landing and check for failures and prior to refueling. On the other hand, if the jets are normally scheduled, they are routed through the “Hold Area” after the mission preparation and prior to pilot’s preflight (the conceptual model in Figure 1 illustrated this concept).

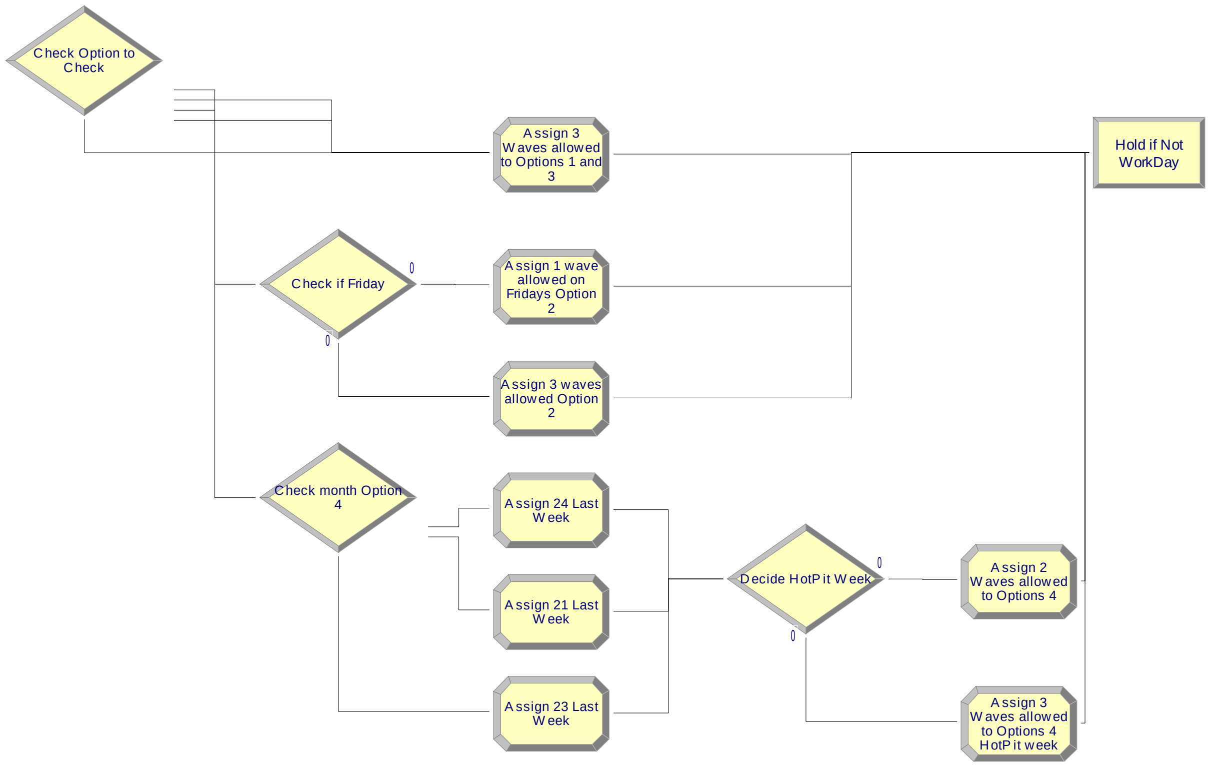


Figure 18. Hold Area (2 out of 5)

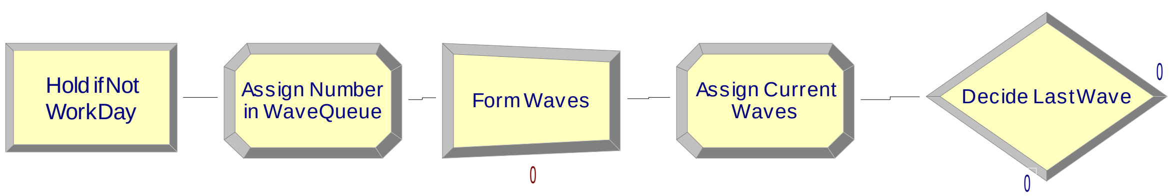


Figure 19. Hold Area (3 out of 5)

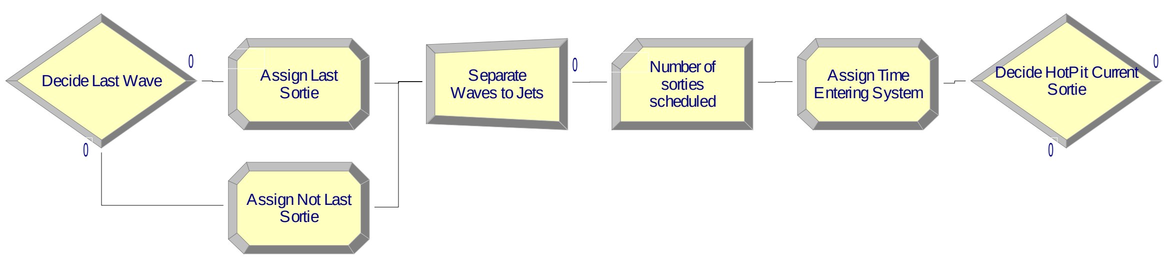


Figure 20. Hold Area (4 out of 5)

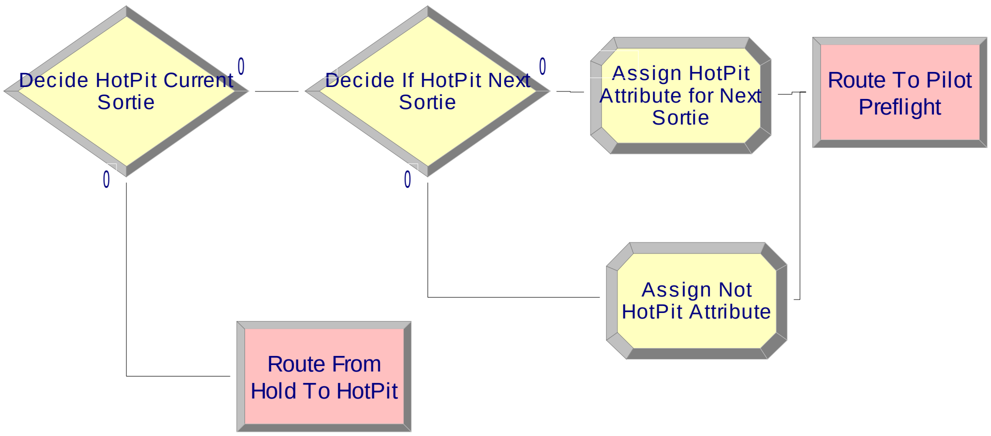


Figure 21. Hold Area (5 out of 5)

Pilot Preflight – Taxi – Takeoff – Fly – Land – End of Runway Areas.

Once the pilot performs his preflight inspection to the jet (Figure 22), he starts the engine and the jet is launched. If there are no ground abort failures (based on Eielson's AFB statistics), the jet taxis towards the "End of Runway" area (Figure 23).

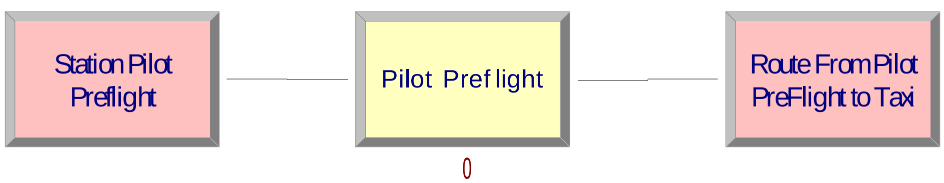


Figure 22. Pilot Preflight Area

In the "End of Runway" (EOR) area, Crew Chiefs and Weapon Specialists inspect the jets just before they takeoff to ensure that the jets are safe for the flight. After the takeoff, the jets may encounter malfunctions that prohibit the mission execution (air abort), and they may be forced to land as soon as possible (Figure 24). If there are no serious failures, the jet flies its mission and it lands while all the variables that use the sortie duration (total hours flown, sorties flown, daily hours flown, flight time per aircraft, time until phase inspection) are calculated (Figure 25).

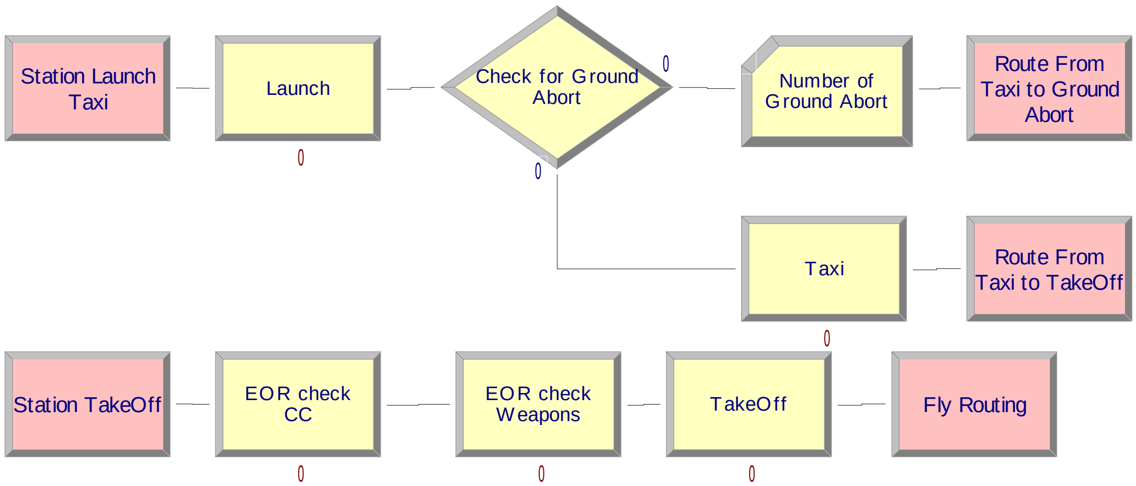


Figure 23. Taxi – End of Runway – Take-off Areas

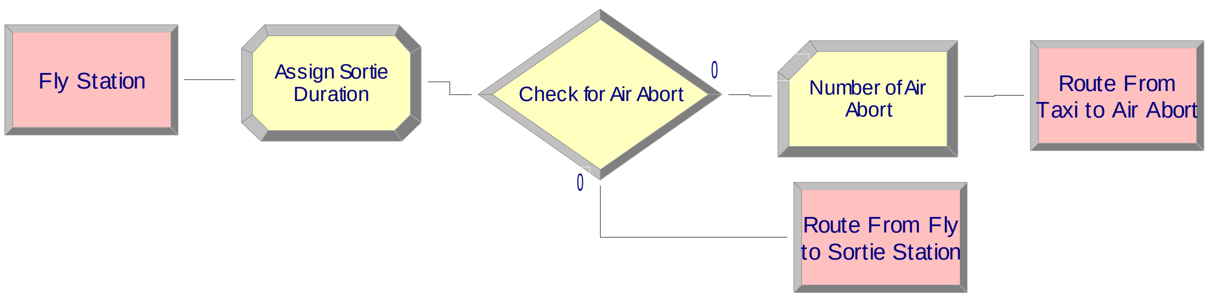


Figure 24. Flying Area

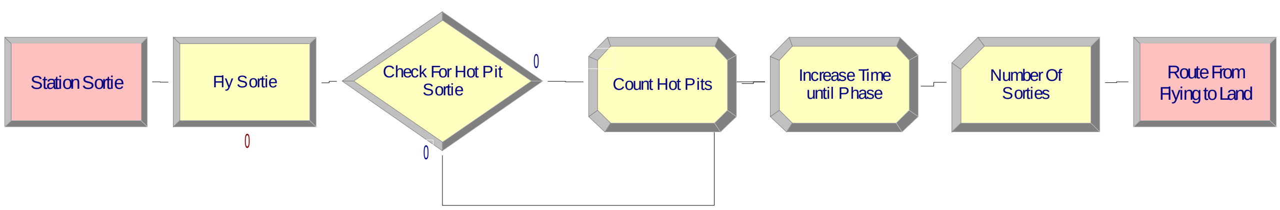


Figure 25. Sortie Area

After landing, a quick "End of Runway" inspection takes place (Figure 26) by both the Crew Chiefs and the Weapon specialists who ensure that the jet is safe to taxi back to the "Parking Area" or to the "Hot-Pit refueling Area" (after a check for failure is performed).

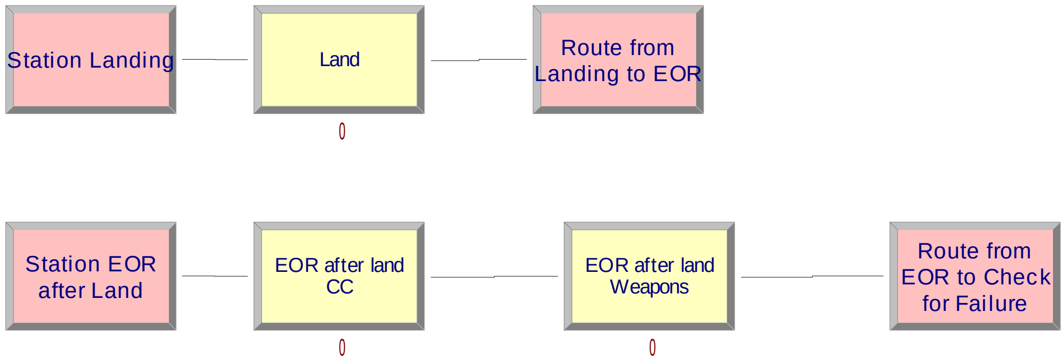


Figure 26. Land – EOR after Land Areas

Air Abort – Ground Abort Areas.

In the "Air Abort – Ground Abort" area, attributes are passed to each jet regarding which Primary Working Center (PWC) will work on the failure that caused the ground or air abort and how long it will take to bring the jet back to operational status. Entities are routed to the "Unscheduled Maintenance Failure Area" (Figure 10) after that. The reason that different areas were used for failures that caused ground aborts, air aborts, and common failures is that the estimation of the failure duration and crew size should be more accurate[10].

Hot Pit Area.

In this area the jets are refueled while the engines are running, and are ready to take off. Because none of the maintenance scheduling philosophies require two consecutive hot-pit sorties, the attribute that controls if the jet will be hot-pit refueled or not, takes the not hot-pit value by the appropriate assign module (Figure 28).

---

[10] Researcher's experience suggested that air abort and ground abort failures take more time to be repaired than after flight failures. A quick look at Eielson's AFB statistics (Appendix "I") confirmed that; air abort failures have a mean of 177 minutes, ground abort have a mean of 97 minutes, and after flight failures have a mean of 65 minutes.

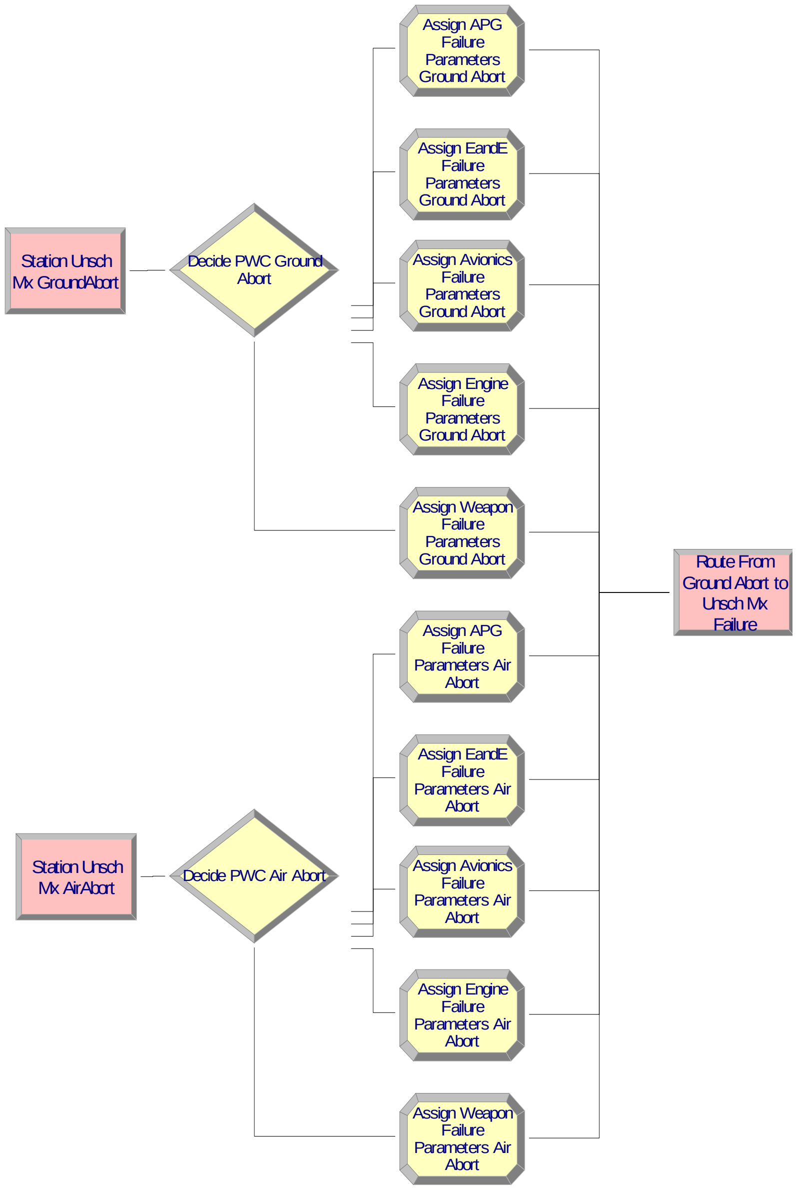


Figure 27. Air Abort – Ground Abort Areas

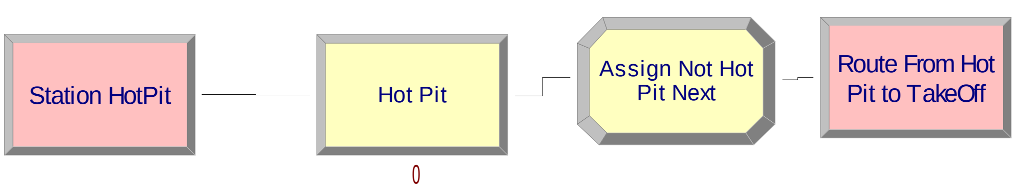


Figure 28. Hot Pit Area

Statistics Area.

This is the area where the daily statistics are collected (Figures 29, 30, and 31). An entity is created at midnight each day to trigger the collection process. If there are no entries and exits into phase inspection that day, the missed hours from phase inspection are calculated by Work In Progress in Phase * 24 hours per day. If there are entries, the hours until the entrance are subtracted and if there are exits, the hours until the exit are added. The missed hours from failure are also calculated in the unscheduled maintenance area. The MC Rate is defined as “The percentage of possessed hours for aircraft that can fly at least one assigned mission”. The “can fly” hours are computed by:

$$CanFly = Possessed - Missedfromfailure - missedfromphase$$

and the MC Rate then is:

$$MCRate = \frac{CanFly}{Possessed} 100\%$$

A VBA module writes the statistics data to Excel for further analysis and all the statistics variables are reset to start counting for the next day’s values.

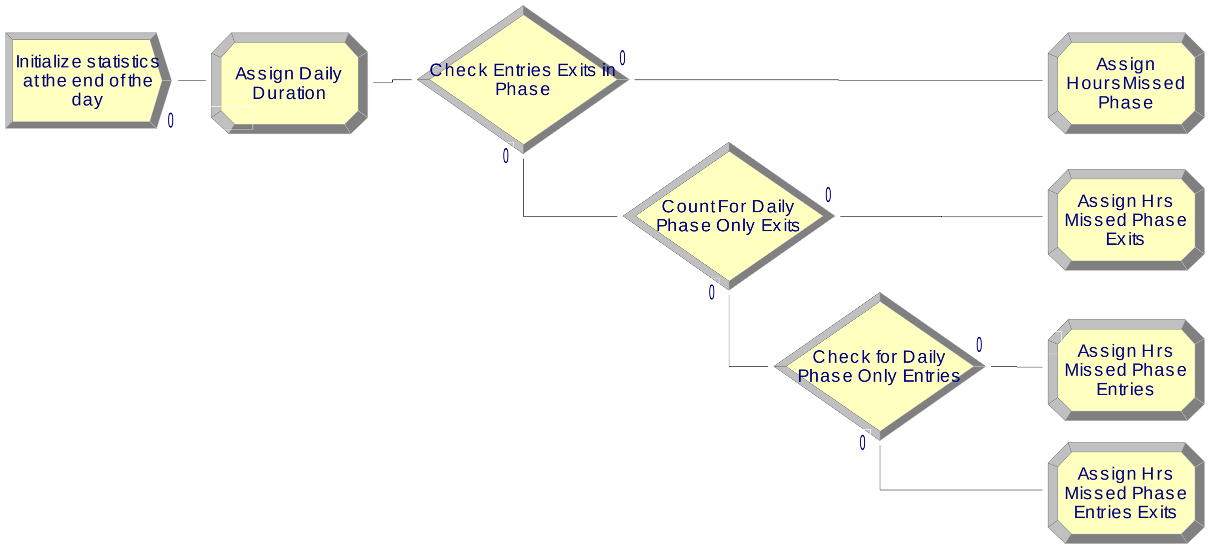


Figure 29. Statistics Area (1 out of 3)

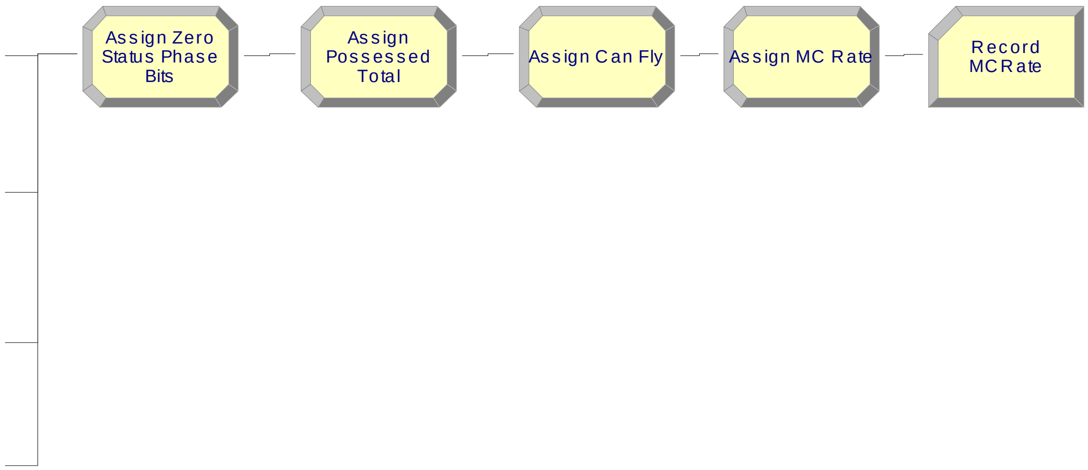


Figure 30. Statistics Area (2 out of 3)

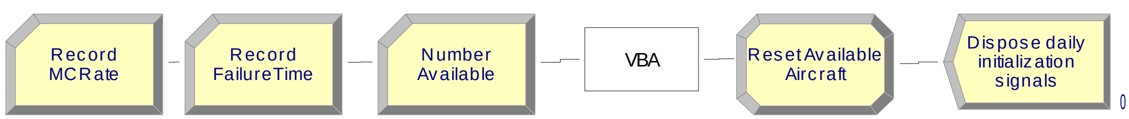


Figure 31. Statistics Area (3 out of 3)

Input Analysis.

Appendix "I" provides an abstract of the theory behind input analysis and fitting distributions and all the analysis that took place regarding the failure data provided by Eielson AFB. The four steps of input analysis (data collection, distribution identification, parameter estimation, and goodness of fit test) were performed for the failure data. Table 2, however, listed some more distributions from which random values are drawn for the applicable processes. This happened in the cases where no reliable data were present[11]. In these cases, the researcher had to rely on some fairly general assumptions but only after performing sensitivity analysis[12] of the output to these ad hoc inputs in order to get a realistic idea of how much faith to put in the model's results.

Because the data represented a time delay, probability distributions were used to capture both the activity's inherent variability as well as the researcher's uncertainty about the value itself. Usually the triangular distribution was used, which can be symmetric or non-symmetric and is bounded on both sides. A triangular distribution can capture processes with small or large degrees of variability and its parameters are fairly easy to understand; it is defined by minimum, most likely (modal), and maximum values, which is a natural way to estimate the time required for some activity. It has the advantage of allowing a non-symmetric distribution of values around the most likely value, which is commonly encountered in real processes. It is also a bounded distribution – no value is less than the minimum or greater than the maximum which may (or

[11] Researcher would like to use the Delphi method to get some input about the processes where data didn't exist. However, the respondents were not F-16 experienced to answer this part of the 1st questionnaire; only 5 data points were inserted and fitting distribution could not be performed.
[12] It is discussed in the validation paragraph below

unfortunately may not) be a good representation of the real process. The three parameters (minimum, most likely, and maximum values) were estimated after thorough discussion with four Subject Matter Experts (SMEs), two from Eielson AFB and two from AFIT. The normal distribution was generally avoided. It used only once (for sortie durations) but in a truncated format to avoid getting very small (and even negative – although Arena would set them to a value of 0) values.

Verification (build the model right).

Verification is concerned with determining whether the conceptual simulation model has been correctly translated into a computer program, i.e., debugging the simulation computer program. Many techniques were used to ensure that the simulation model was built correctly:

1. Modular programming was used, the model was built in logical "chunks" and the complexity was added gradually (and only if needed). In general, it is always better to start with a "moderately detailed" model, which is gradually made as complex as needed, than to develop "immediately" a complex model, which may turn out to be more detailed than necessary (Law & Kelton, 2000).
2. A close look to the units of time measurement was taken to verify that they are consistent (for example all the process durations are in minutes except the sortie duration which is in hours and the phase maintenance duration which is in days).
3. Various plots were made and variables were listed to help in debugging the model.
4. Long-run animation was used to check that the entities were following all the paths in the model.

5. The different maintenance scheduling philosophies are passed via a parameter set to the same model, in order to build only one model and not several ones. Building several models to examine the different maintenance scheduling philosophies would be error prone because each change in one model should be also made at all the other models.
6. The VBA debugger was used to debug the VBA portion of the simulation model while the model was running.

Validation (build the right model).

Validation is the process of determining whether the simulation model (as opposed to the computer program) is an accurate representation of the system, for the particular objectives of the study. Several techniques are used for increasing model validity and credibility:

1. The collection of high-quality information and data on the system which is subdivided as follows:
   a. Conversations with Subject-Matter Experts. The researcher worked closely with people who are intimately familiar with the system (two classmates maintenance officers and two officers assigned from Eielson AFB to work on the research effort)
   b. Failure data came from Computer Aided Maintenance System (CAMS) which contains the most accurate failure data within the Air Force (Stetz, 1999; Commenator, 2001). This information is assumed to stay the same for the systems that are modeled for this research.

c. Relevant results from similar simulation studies. The common input parameters between the simulation model and previous studies do not greatly differ.

2. Interaction with the sponsor on a regular basis. His knowledge of the system contributed to the actual validity of the model.
3. Validation of the conceptual model by two Subject-Matter experts.
4. Validation of components of the simulation model using sensitivity analysis. When arbitrary assumptions were made about the value of parameters or the choice of a distribution, sensitivity analysis was also performed to determine if the specific assumption appeared to influence the output of the model. There was no case on this research where the arbitrarily chosen distribution or parameter value appeared to be a problem.
5. Output validation from the overall simulation model. Several tests were performed for comparing the model with similar real world systems. For example, the MC Rates produced by the model are validated by ensuring they are very close to actual reported data. A detailed sensitivity analysis (described in paragraph 4.4) contributed in the validation process.

Designed Experiment - Factorial Design.

A designed experiment is one for which the analyst controls the specification of the treatments and the method of assigning the experimental units to each treatment. The basic purpose of an experimental study is to examine the possible influences that one factor or condition may have on another factor or condition; in other words, it examines

cause and effect relationships. It does so by controlling for all factors except those whose possible effects are the focus of investigation.

Because more than one independent variable is studied, a factorial design approach was deemed appropriate for answering the fourth investigative question. Multifactor studies allow the researcher to determine whether the independent variables interact in some way as they influence the dependent variable. They can also include some factors of secondary importance to permit inferences about the primary factor with a greater range of validity (Neter, Kutner, Nachtshein, & Wasserman, 1996).

Simulation modeling helps in minimizing two kinds of bias in designed experiments: the selection bias and the measurement bias. Selection bias occurs when the experimental units for two treatment groups are not similar. In a well-programmed simulation modeling, all the experimental units can be similar. Synchronization (common random numbers) can be used among the various replications to eliminate some of the noise of the model and more closely represent the differences between the alternatives. Measurement bias can occur when unrecognized differences in the evaluation process exist. This is not the case in this research because the dependent variables are objectively defined and calculated by the simulation model.

The type of factorial design that is used depends on the number of dependent variables that are defined by the second investigative question, the number of needed treatment levels, and the sample sizes needed based on the power of the study. The protocol of the designed experiment is presented in the following Chapter IV because the results of the first three investigation questions are needed. The protocol includes the

factors, the factor levels, the response variables, the pilot runs, and the number of replications.

Summary

Chapter III has provided the methodology that was undertaken in this research in order to achieve the research objectives. The Delphi study, the content analysis and the simulation model were explained. The various model process times were presented and the method of obtaining their values was analyzed. The undertaken methods for enhancing the verification and validation of the model were also highlighted. The Design of Experiment protocol was left for the next chapter because the results of the first three investigative questions are needed. The following chapter will present the results of the undertaken methodology and will provide the answers to the investigative questions.

IV. Analysis and Results

Introduction

The previous chapter defined the methodology that was used for answering the investigative questions of this research. This chapter defines the steps in setting up and performing the analysis and presents the results of this analysis. These steps include the analysis of the Delphi responses, the presentation of the content analysis results, and the determination of the appropriate length and number of model replications to produce data that can be statistically analyzed. This discussion then presents the statistical analysis of the results from the simulation runs.

Scheduling Philosophies (Question 1)

What are the commonly used F-16 unit scheduling philosophies that need to be compared in terms of improving the long term health of the fleet?

As the reader can recall from chapter III, the answer to this question is identified by analyzing the 3-round Delphi study and the sponsor's and personal experience. After the initial solicitation letter for participating to the Delphi study, 35 volunteers were identified. The first questionnaire (Appendix "F") was answered by 33 respondents with 16 of the responses containing comments (see Appendix "K") that were parsed, categorized, and used when the 2nd questionnaire (Appendix "G") was conducted.

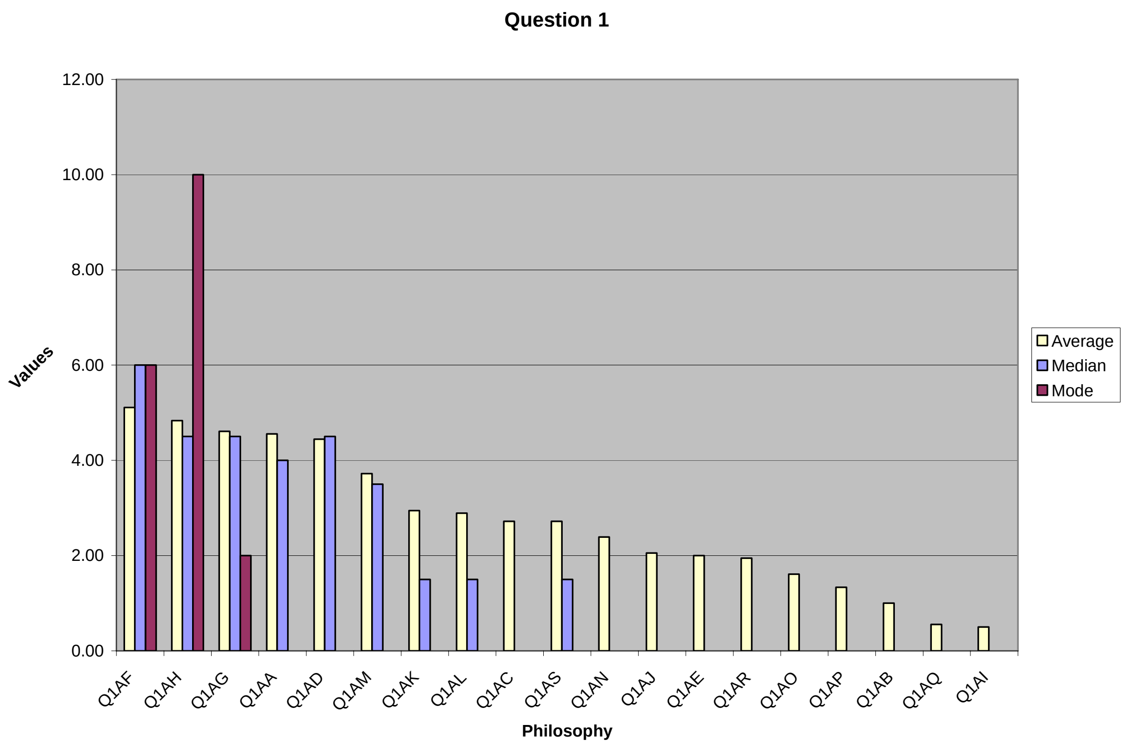
The second questionnaire was answered by 18 respondents and their answers are summarized in Figure 32. Three point estimates were used to illustrate the ranking of their responses: the mean (the sum of rankings divided by the number of responses), the median (the middle number when the grades are arranged in ascending order), and the

mode (the ranking order that occurred most frequently in the responses). In Figure 32, the results are presented in mean descending order. The median seems to be preferred rather than the mean, because single extreme answers can pull the mean unrealistically (Linstone et al., 2002). However, the top-5 ranking remains the same regardless of the point estimate used.

For better visual representation of the results, box plots[13] were plotted and they are illustrated in Appendix “L”. By using the shortest half indication (the most dense 50% of the observations), as described in Appendix “L”, the top-5 list is still the same. In the third (and last) round of the Delphi study, the participants were asked to agree or disagree with the top-5 philosophies identified above. The last questionnaire was answered by 18 respondents and 14 of them agreed with the top-5 list. The remaining four respondents disagreed with only one philosophy in the top-5 list. Two of them disagreed with the 30 days limit (Q1AG response) of keeping a plane down, one of them suggested that minimizing the number of configurations should be in the top-5 and one of them disagreed with the first choice of allowing at least 12 hours between last down and first go (or paraphrasing it keeping the flying window at most at 12 hours).

Sponsor’s inputs were that Eielson AFB wanted to check the “1 wave on Fridays” alternative and the “12 turn 10 jets for 3 weeks and 10 hot pit 10 turn 8 jets for the last week of the month” alternative. Sponsor’s inputs were incorporated in the simulation model along with the top-5 from the Delphi study.

[13] In box plots the median, the mean, the 95% confidence interval of the mean, the inter-quartile range and the possible outliers are displayed.



Q1AF: At least 12 hours between last down and first go
Q1AH: Ensure enough downtime for scheduled and unscheduled maintenance
Q1AG: Don't keep a plane down more than 30 days
Q1AA: "Balanced" approach of spreading the schedule out equally throughout the week/month
Q1AD: 2.5 hours between land - takeoff
Q1AM: Minimize the number of configurations
Q1AK: Increase Average Sortie Duration (ASD)
Q1AL: Keep UTE rate under certain level
Q1AC: 1 "normal" wave on Fridays VS 2 "normal" waves
Q1AS: The more the aircraft flies the more reliable it is
Q1AN: No cann birds for sake of MC Rate
Q1AJ: Fly heavy at the beginning of the fiscal year and let off later
Q1AE: Adjusted turn patterns to accommodate fewer front lines
Q1AR: Sortie surge once per month VS once per quarter
Q1AO: No-fly Fridays
Q1AP: Pit and Go daily VS two to three times per week
Q1AB: 1 "large" wave on Fridays VS 2 "normal" waves
Q1AQ: Schedule more sorties at night to allow more robust day shifts
Q1AI: Extended VS condensed flying window

Figure 32. 1st Question 2nd Survey results

An assessment of the identified as top-5 by the Delphi study philosophies follows:

1. **At least 12 hours between last down and first go**: This philosophy can not be incorporated as a philosophy itself because of the restrictions that would be placed on operations in scheduling for different types of missions. However, based on the other philosophies, it can be used as a measurement in identifying the philosophy that can more easily meet the maximum 12 hours flying window in the sortie generation process. For the purpose of this research, the flying window is used as a dependent variable in order to compare the different scheduling philosophies in terms of maintenance effectiveness.

2. **Ensure enough downtime for scheduled and unscheduled maintenance:** This is the ultimate rule in aircraft maintenance and no deviation is allowed. Deviation from this rule may cause flight safety issues. It was assumed for the purpose of this research that maintainers have the time to perform the required scheduled and unscheduled maintenance.

3. **Don't keep a plane down more than 30 days:** The ultimate goal should be to not keep a plane down more than 1 day. However, valid reasons such as untraceable failures and lack of supplies may lead to keeping a plane down more than anticipated. Respondents selected this philosophy as important, keeping in mind that if a jet is not flying for a long period of time it has a tendency for seals to dry and hydraulics to leak[14] and it requires mandatory additional inspections that waste maintenance time. However, this should not stand as a maintenance

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[14] Based on the explanation of a participant

philosophy itself but it should be the goal for every philosophy (although the arbitrary 30 days limit warrants more research). The two main reasons for letting this happen are captured by the maintenance predicament to fix the jets and the supply difficulty to provide the required materials. If both of these reasons are no longer of concern, then there is no reason to leave the jets down more than 30 days. So, the ultimate goal should be to improve the fix rates, the Not Mission Capable for Maintenance Rate (NMSM) and the Not Mission Capable for Supply Rate (NMCS).

4. **Balanced approach of spreading the schedule out equally:** "Smart" surges seem to be better than the regularly scheduled flying program. For instance, at Eielson AFB it is not smart to schedule surges during the snowy winter months. This philosophy depends on the climate and the weather conditions of each base. For the purpose of this research, the balanced approach is a baseline monthly schedule that was proposed from Eielson AFB and the unbalanced approach is simulated by a percentage increase or decrease in the daily schedule compared to the baseline schedule.
5. **2.5 hours between land – takeoff:** This is checked by the simulation model during the sensitivity analysis using various durations between waves. So, different values are checked and the optimal solution is addressed.

Performance Metrics (Question 2)

What are the important performance metrics USAF uses to capture long term health of the fleet and maintenance effectiveness to meet unit sortie production goals?

As the reader can recall from chapter III, the answer to this question is identified by assessing the results of a content analysis, by analyzing the 3-round Delphi study, and by the proposal of the 2001 Chief of Staff Logistics Review (Figure 33).

Content Analysis Results.

The results of the content analysis are presented in Table 3. “D” denotes dependent factor while “I” denotes independent factor. The table is presented in descending order of the times each aircraft maintenance performance factor was used as a dependent factor in the scanned researches (only the factors that were used at least once as independent factor are illustrated; the whole table can be found in Appendix “M”). Mission Capable Rate (MC Rate) is by far the mostly used dependent variable (metric). 8 out of 9 researchers used MC Rate as a dependent variable of their researches while 3 out of those 8 used only MC Rate to capture their findings. Scheduling Effectiveness rate is the second in the list, and Not Mission Capable Maintenance Rate (NMCM Rate), Maintenance ManHours per Flying Hour, Maintenance Scheduling Effectiveness, and Repeat Discrepancy Rate follow. Only the dependent variables were used for this analysis because of the focus of the 2nd investigative question. We need to answer which are the performance measures that capture the long term health of the fleet (dependent) while the independent factors in the study are the maintenance philosophies that are identified by the 1st investigative question.

Using the same factor as the dependent variable does not mean that these research efforts are correlated and the usefulness of the factors can not be derived from the number of times each factor was used in previous research efforts. On the other hand, it

means that these factors were so important for the research efforts that most of the researchers used them.

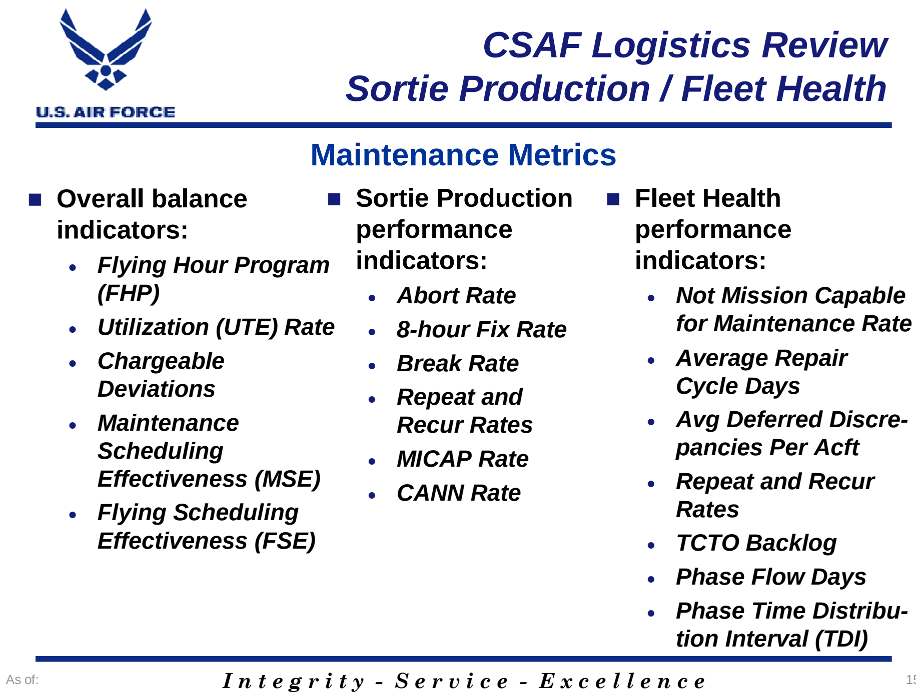


Figure 33. Metrics from CSAF Logistics Review

Delphi Method Results.

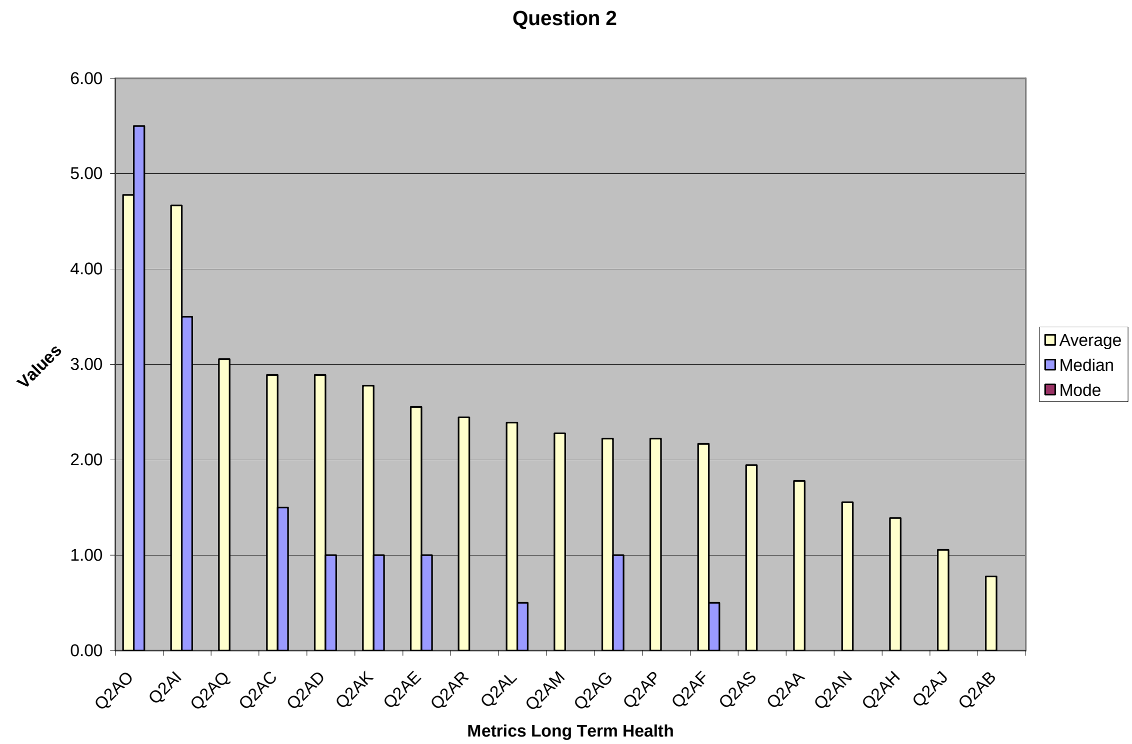
Two different questions were asked about metrics during the Delphi study: one about the metrics that capture the long term health of the fleet and the other about the metrics that capture the maintenance effectiveness to meet unit sortie production goals. The first questionnaire (Appendix “F”) was answered by 33 respondents but only 16 of the responses were useful (the other contained no comments). All these responses concerning the fleet health and the maintenance effectiveness metrics are presented in Appendices “N” and “O” respectively (since the information cannot be directly or through identifiers linked to the respondents). These responses were parsed, categorized and the 2nd questionnaire (Appendix “G”) was conducted.

Table 3. Content Analysis Results for Dependent Factors

Aircraft Maintenance Performance Factor	**Researchers**								
"D": Dependent factor, "I": Independent factor	Davis & Walker (1992)	Jung (1991)	Gilliland (1990)	Diener & Hood (1980)	Allison (1999)	Beabout (2003)	Commenator (2001)	Oliver (2001)	Faas (2003)
Mission Capable Rate (MC Rate)	D	D	D	D	D	D		D	D
Scheduling Effectiveness Rate				D		D	D		D
Not Mission Capable Maintenance Rate (NMCM Rate)	I	I		D			D	I	D
Maintenance ManHours Per Flying Hour	I	I	D	D			D		
Maintenance Scheduling Effectiveness			D			D	D		
Repeat Discrepancy Rate			D	D			D		
Air Abort Rate	I	I			D		I		D
Ground Abort Rate				D			I		D
Aircraft Sortie Utilization Rate	I	I					I		D
Not Mission Capable Supply Rate (NMCS Rate)	I	I					I		D
Aircraft Hourly Utilization Rate	I						I		D
Aircraft Break Rate		I			D		I		
Not Mission Capable Rate (NMC Rate)	I	I							D
Air Aborts		I							D
Number of Aircraft Fixed in 8 Hours							D	I	
Sorties Flown		I							D
Sorties Scheduled		I							D
Average Hours Per Inspection				D					
Average Turn Time				D					
Direct Labor Rate				D					
Enroute Labor Rate			D						
Home Station Reliability			D						
Maintenance Air Aborts			D						
Number of Aircraft Fixed in 4 Hours							D		
Recur Discrepancy Rate							D		
Training Reliability			D						

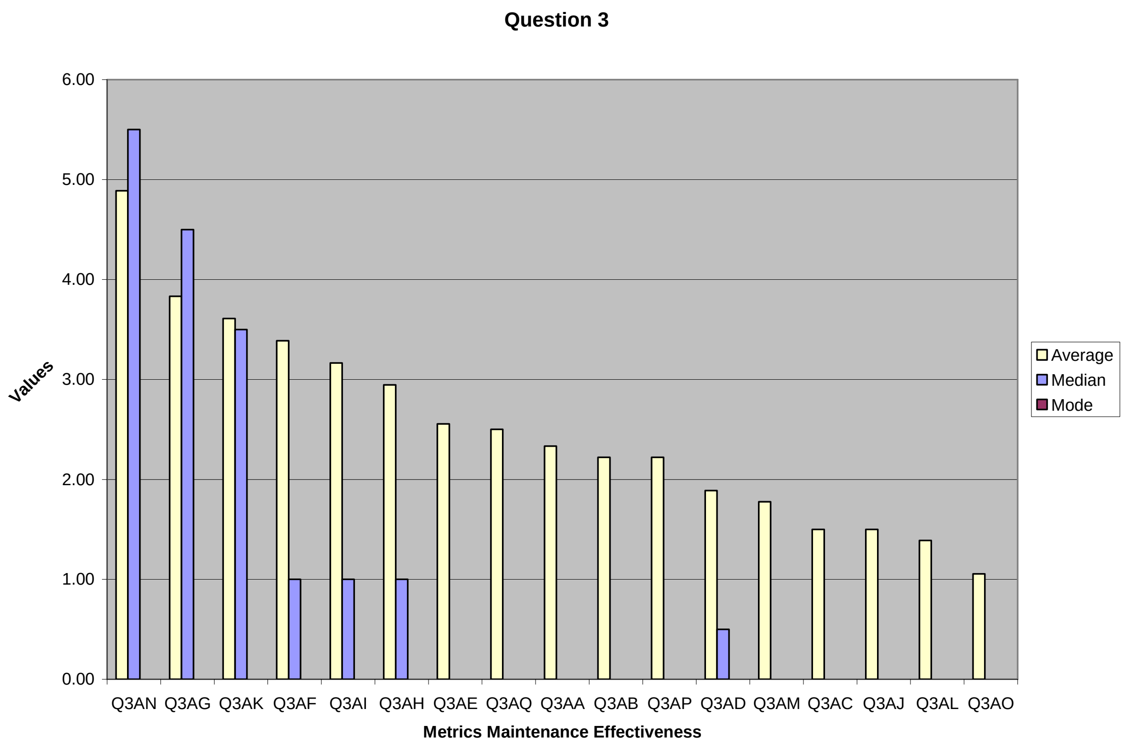
The second questionnaire was answered by 18 respondents and their answers to the two-part 2nd investigative question are summarized in Figures 34 and 35. Three point estimates were used to illustrate the ranking of their responses: the mean, the median, and the mode. In Figures 34 and 35, the results are presented sorted by the mean in

descending order. For better visual representation of the results, box plots were plotted and they are illustrated in Appendix "P".



Q2AO: Repeat / Recur Rate
Q2AI: MC Rate
Q2AQ: Time each aircraft spends broken
Q2AC: Break rate
Q2AD: Cann Rate
Q2AK: Number of discrepancies during phase inspections
Q2AE: Ground Abort Rate
Q2AR: TNMCM
Q2AL: Number of K write-ups – Delayed Discrepancies
Q2AM: Phase Flow Days
Q2AG: Maintenance Scheduling Effectiveness Rate
Q2AP: TCTO Backlog
Q2AF: Maintenance discrepancy fix rates
Q2AS: UTE Rate
Q2AA: % of scheduled sorties that accomplished full mission objectives
Q2AN: Phase Time Distribution Interval
Q2AH: Maintenance Non-Deliverables
Q2AJ: Number and type of exceptional write-ups
Q2AB: Amount of time taken to complete Depot Maintenance

Figure 34. 2nd Round of Delphi Study – Metrics that Capture the Long Term Health of the Fleet



Q3AN: Repeat / Recur Rate
Q3AG: Ground abort rate
Q3AK: On-time departure rates
Q3AF: Flying scheduling effectiveness rate
Q3AI: MC Rate
Q3AH: Maintenance discrepancy fix rates
Q3AE: Fix rates
Q3AQ: TNMCM
Q3AA: (Number of ac scheduled for the day's flying schedule) / (Number FMC ac) 2 hours prior first launch
Q3AB: Cann rate
Q3AP: Sortie completion rate
Q3AD: Discrepancies awaiting maintenance (AWM)
Q3AM: Phase time completion stats
Q3AC: Comparison of number of schedule change requests to number accepted / rejected / accomplished
Q3AJ: Mission Success Rate
Q3AL: Phase backlog
Q3AO: Schedule "fill" rates

Figure 35. 2nd Round of Delphi Study – Metrics that Capture the Maintenance Effectiveness to Meet Unit Sortie Production Goal

In the third (and last) round of the Delphi study, the participants were asked to agree or disagree with the top-5 metrics identified by the 2nd round of Delphi study. The

last questionnaire was answered by 18 respondents and 13 of them agreed with the top-5 metrics regarding the long term health of the fleet and 12 of them agreed with the top-5 metrics regarding the maintenance effectiveness to meet unit sortie production goals.

The disagreements were as follows:

1. Metrics regarding fleet health
    i. Repeat / recur rate should not be included in the top-5 list because it reflects more aspects of improper maintenance. It should be replaced by number of discrepancies during phase inspection.
    ii. Cann rate should be replaced by delayed discrepancies because Cann rate is more an indication of the supply system rather than the fleet health. This information was brought by two respondents.
    iii. Time each aircraft spends broken should be replaced by number of discrepancies during phase inspection.
    iv. % of scheduled sorties that accomplished full mission objectives should be included in the top-5 list.
2. Metrics regarding maintenance effectiveness
    i. Fix rates should replace MC Rates because MC Rates are also impacted by scheduled maintenance
    ii. On-time departure rates metric should not be included because it also reflects operator errors that resulted in late launches (e.g. late crew shows, departure delays). This information was brought by two respondents.
    iii. Repeat / recur rate should be replaced with sortie completion rate.

iv. Repeat / recur rate should not be the most significant metric of effectiveness and production.

Health of Fleet Metrics Analysis.

The only two metrics that appear in all the selection methods regarding the health of the fleet are the Not Mission Capable for Maintenance Rate (in the form of Mission Capable Rate in the Delphi study) and the Repeat / Recur Rate.

Mission Capable rate (MC Rate) seems to be a significant metric that captures the long term health of the fleet. MC Rate was the mostly used dependent variable in the content analysis; it was also listed in the Delphi study; and a part of it, the Not Mission Capable for Maintenance Rate (NMCM Rate) was identified by the CSAF Logistics Review as a fleet health performance indicator. It is felt that the NMCM Rate illustrates the long term fleet health better in comparison to the MC Rate which may incorporate supply problems as well.

The Repeat / Recur rate could also be a significant metric but it has the major disadvantage of reflecting aspects of improper maintenance and is not only a fleet health indicator. Although this metric was chosen by the Delphi study, there was a disagreement during the final round that introduced this problem; it is felt that further research is required to understand what part of the Repeat / Recur rate is due to improper maintenance and what part is caused by the "unhealthiness" of the fleet. The same disadvantage may also exist in the NMCM Rate but in a smaller degree. The percentage of the NMCM Rate that is caused by improper maintenance should be significantly smaller than the percentage of the Repeat / Recur Rate that is caused due to the same reason, because NMCM Rate accounts for the total number of failures while Repeat /

Recur Rate only accounts for the repeated ones. This means that improper maintenance should have a significantly larger impact in the Repeat / Recur Rate compared to the NMCM Rate.

Maintenance Effectiveness Metrics Analysis.

The Repeat / Recur rate was proposed by the Delphi Study as the top metric. It is listed in the CSAF Logistics Review as a sortie production performance indicator, and the content analysis proposed the Repeat Discrepancy rate in the top-5 metrics as a dependent factor used by previous researchers. However, it is felt that the Repeat / Recur rate focuses more on the quality part of the effectiveness, which might be jeopardized by several other reasons. As mentioned in Appendix "B", a high Repeat / Recur rate may indicate a lack of thorough troubleshooting, inordinate pressure to commit aircraft to the flying schedule for subsequent sorties, or a lack of experienced, qualified, or trained technicians. Further research is suggested regarding this metric to understand what part of it is due to improper maintenance and maintenance ineffectiveness and what part is caused by the "unhealthiness" of the fleet.

The abort rates and the fix rates cannot be used in the model as dependent variables because they were calculated from Eielson's AFB data and were used as independent variables in the simulation model. The logic that affects the abort and the fix rates cannot be investigated unless real data exist from bases that use different maintenance scheduling philosophies or a further qualitative research focused on the influence of the specific maintenance scheduling philosophies on the abort and fix rates is conducted. For the purpose of this research, metrics that capture the effect of

maintenance to the flying schedule and how different philosophies affect the maintenance schedule are needed.

An interesting metric was proposed by the Delphi study: discrepancies awaiting maintenance (AWM). This metric was ranked seventh (with median decreasing order) and it clearly illustrates the effect that different maintenance scheduling philosophies might have on the flying schedule. This metric can be calculated by the simulation model by adding the average number of entities in each maintenance activity queue. The average time in all the maintenance activity queues is also important because it captures the not mission capable time due to the scheduling philosophy and not because of the maintenance activity which may be influenced by the existence of experienced or not personnel.

A more obvious metric that wasn't proposed from the Delphi Study but which may help in comparing the various maintenance scheduling philosophies is the flying window length (the time from first takeoff to last land of the day). The flying window drives shift scheduling, and operations and maintenance are not the only agencies involved in sortie generation. Fuels management, air traffic control, the weather squadron, and many others are also involved. Management supervision must also cover the entire flying window. The length of the flying window determines effectiveness of the maintenance fix shift. For this research, the flying window is not established a-priori to negatively influence the scheduling philosophy, but it is computed as a dependent variable assuming that generally, a shorter flying window is better (the work to be done can be done in shorter time and is not forced to be done in shorter time). A survey

respondent that proposed the condensed flying window as a maintenance scheduling philosophy quoted:

The primary benefit to shortened flying windows is that it allows greater flexibility to managers in allocating their workforce to shifts throughout the maintenance day. A shortened flying window means that day shift can do the majority of daily generation actions on the planes to meet the daily schedule. You can put mostly 5-level and 3-level crew chiefs, as well as cut-trained 3-level specialists on this shift to generate and recover the aircraft. Swing shift becomes your most vital shift for actual maintenance actions and you can stack your shift with experienced crew chiefs and specialists to ensure broken planes get fixed in time for the next days flying. By regulation, mids is only supposed to consist of a servicing crew - very little heavy maintenance can get done. A shortened flying window means shift schedules can be tailored to the type of maintenance that will take place. Longer flying windows means two shifts are involved in generation and recovery. Turn-over is always cheated since planes are landing as swing shift is arriving to work - this hampers effective communication.

3rd Investigative question

How does each one of the various scheduling philosophies affect the long term health of the fleet and maintenance effectiveness to meet unit sortie production goals?

Analysis.

A sensitivity analysis was conducted to identify how each one of the various scheduling philosophies affects the long term health of the fleet and the maintenance effectiveness to meet unit sortie production goals. For this purpose, several simulation runs were conducted. Each run had duration of 4 years and a warm-up period of 100 days. The duration of the simulation run and the warm-up period were determined after the examination of several pilot runs like the one illustrated in figures 36 and 37. It seems that after almost 100 simulation days the average number of aircraft awaiting maintenance and the total time of aircraft in maintenance queues level out. In addition,

there is no need to run the simulation for more than 4 years because there is no significant impact in those two metrics (it seems that they have already reached their limits).

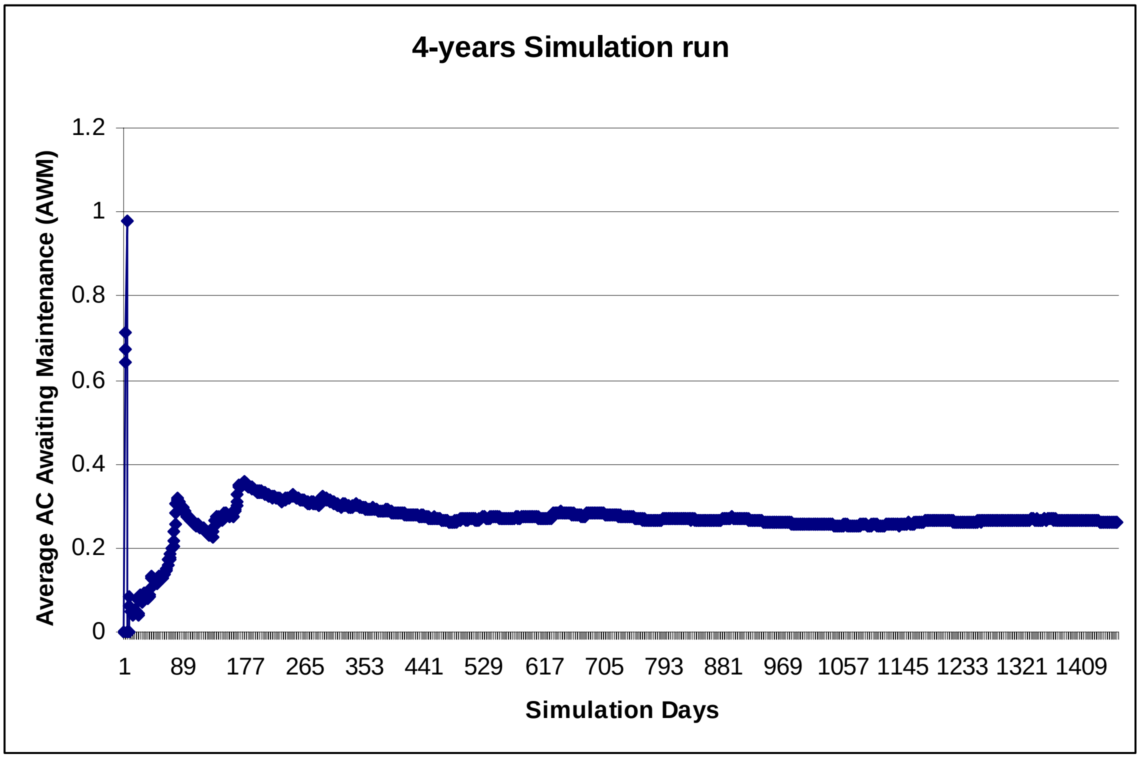


Figure 36. 4-years Simulation Run for Average Aircraft Awaiting Maintenance

The variables that were examined are:

1. The maintenance scheduling philosophy with the following factor levels:
    a. 3 waves Monday to Friday
    b. 3 waves Monday to Thursday and 1 wave on Friday
    c. 12 turn 10 aircraft for 3 weeks, and 10, hot pit 10, turn 8 aircraft for 1 week
2. The time between land and takeoff with four factor levels:
    a. 2 hours

    b. 3 hours

    c. 4 hours

    d. 5 hours

3. The balanced – unbalanced approach with three factor levels:

    a. Balanced approach (the simulation program tries to smooth the flying schedule per day as much as possible)

    b. Unbalanced approach (10%) (the daily flying schedule is randomly increased or decreased by 10% -- eventually the sorties production tends to be equal with the balanced approach)

    c. Unbalanced approach (20%) (the daily flying schedule is randomly increased or decreased by 20% -- eventually the sorties production tends to be equal with the balanced approach)

4. The Sortie Production Goal with five factor levels

    a. 20% decrease in proposed flying schedule per month

    b. 10% decrease in proposed flying schedule per month

    c. The proposed flying schedule itself

    d. 10% increase in proposed flying schedule per month

    e. 20% increase in proposed flying schedule per month

5. The maintenance personnel

    a. 20% decrease in maintenance personnel

    b. 10% decrease in maintenance personnel

    c. The proposed maintenance personnel

    d. 10% increase in maintenance personnel

e. 20% increase in maintenance personnel

The factor levels were selected to be feasible concerning a normal flying squadron and to capture a significant range in order to illustrate potential problems in fleet health and maintenance effectiveness. The output variable of interest for the fleet health was the Not Mission Capable for Maintenance rate (NMCM Rate) and for the maintenance effectiveness the discrepancies awaiting maintenance (AWM), the average time in maintenance activity queues (ATQMA) and the flying window as described in paragraphs 4.3.3 and 4.3.4 respectively.

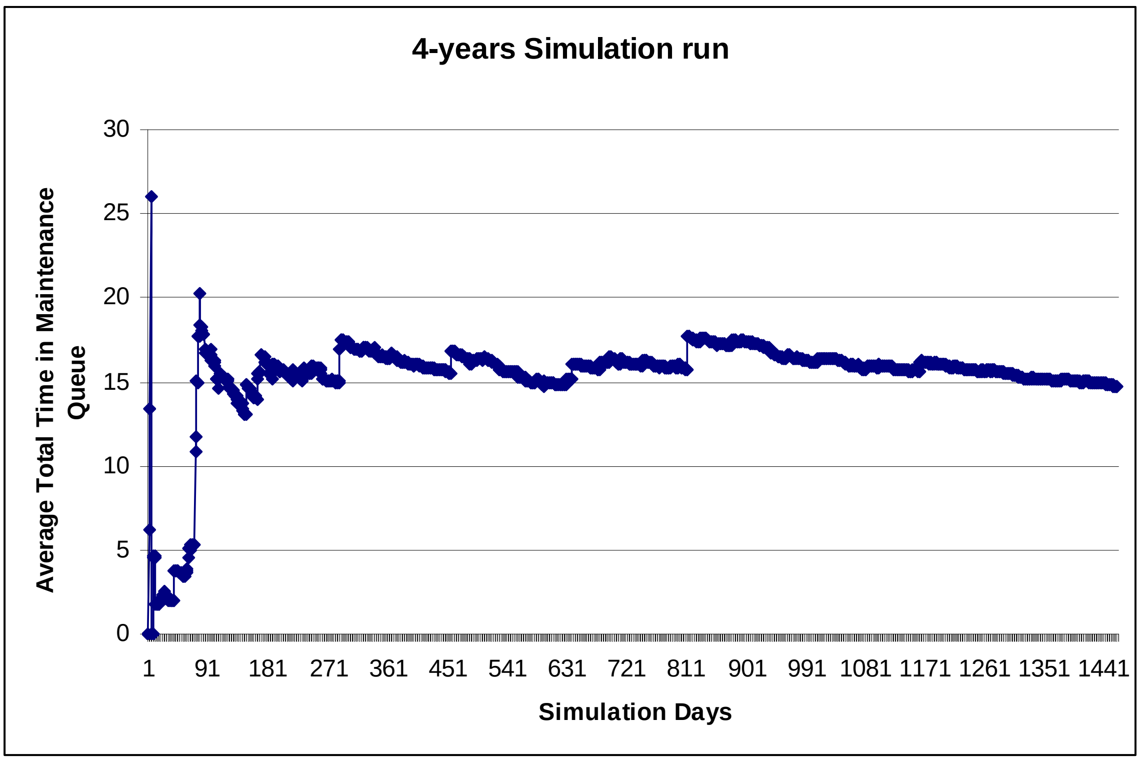


Figure 37. 4-years Simulation Run for Average Total Time in Maintenance Queues

Long Term Health of the Fleet.

Figure 38 illustrates that the 3 weeks 12 turn 10 jets and 1 week 10 hot pit 10 turn 8 jets produced the best results regarding the fleet health[15]. The 1-wave on Friday approach was better that the 3-waves all week approach. It also seems that Eielson AFB is wisely manned. Figure 39 shows that 10% reduction in maintenance personnel significantly impacts all the scheduling options while a 20% increase in maintenance personnel does not affect any of the options. Therefore, no change in personnel is suggested regardless the scheduling option.

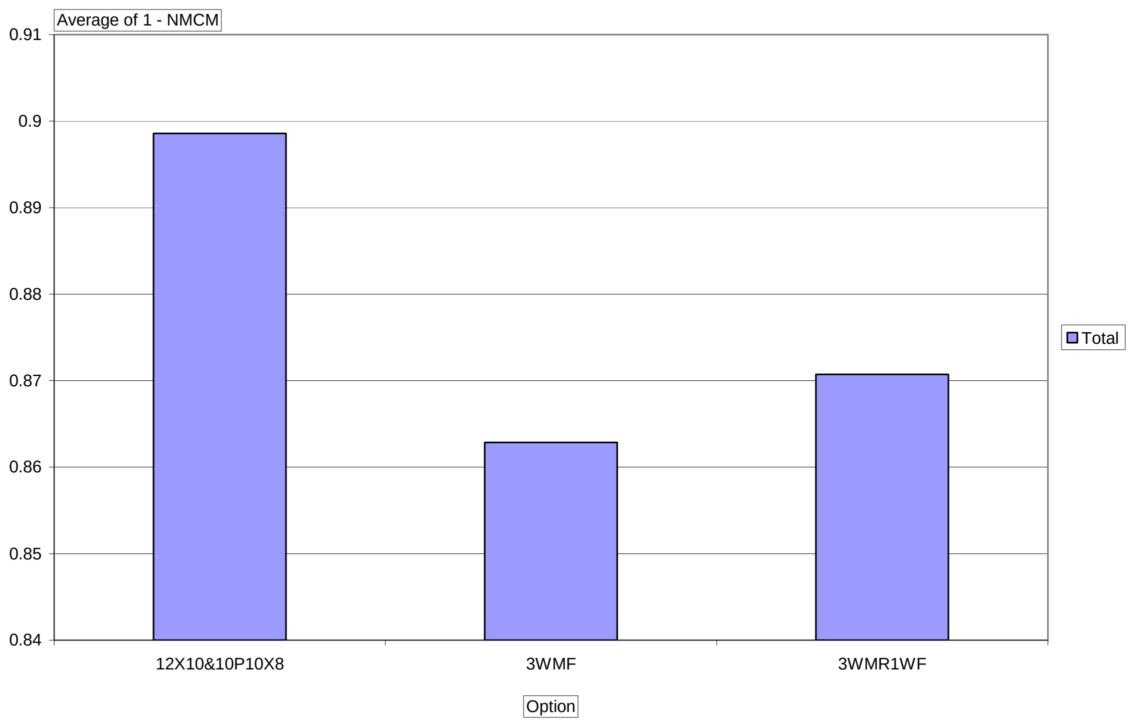


Figure 38. NMCM Rate Depending on Scheduling Philosophy

[15] All the figures that present fleet health results, illustrate the 1 – NMCM Rate so larger values denote better results.

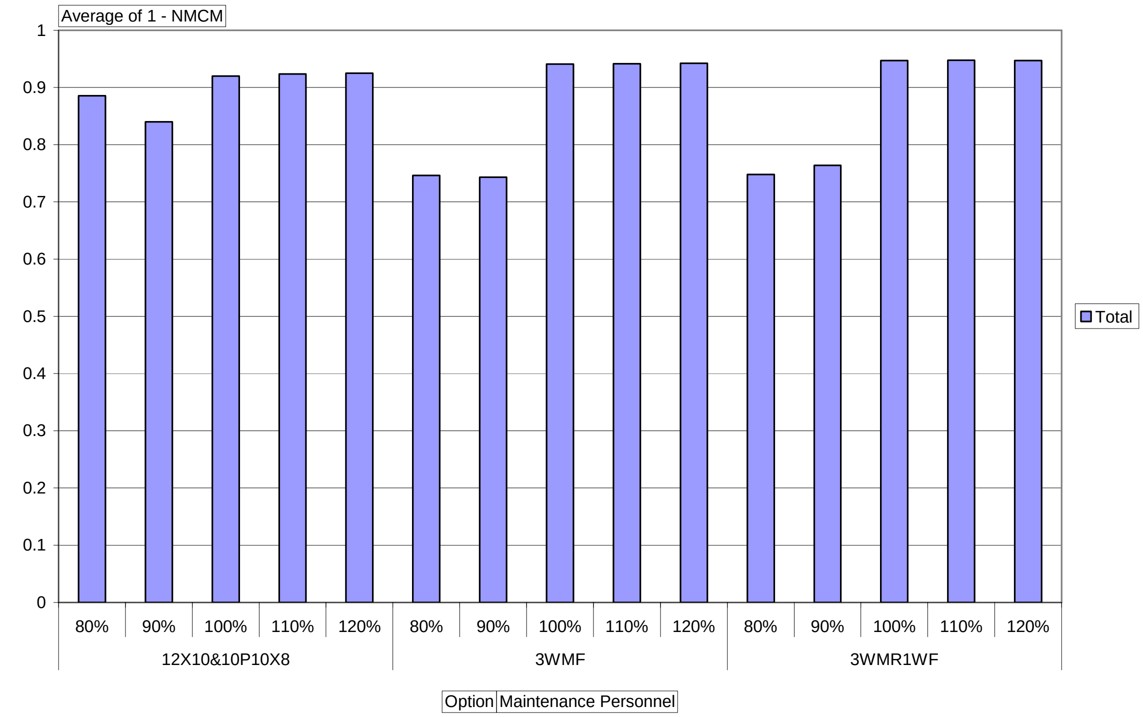


Figure 39. NMCM Rate Depending on Scheduling Philosophy and Maintenance Personnel

Before analyzing the effect of the various scheduling options on the fleet health and maintenance effectiveness, the conclusion that Eielson AFB is wisely manned needs to be emphasized based on the fact that by reducing the maintenance personnel the squadron is unable to produce the required sorties regardless the scheduling option (Figure 40). It is also illustrated that generally by increasing the maintenance personnel there will not be any significant impact in sortie production. Of course this conclusion requires further investigation to determine which specific maintenance specialty is the bottleneck in sortie production. Because manning is not itself the main focus of this research it will be left for

future research[16]. For the purpose of this research only potential increase in the maintenance personnel is examined.

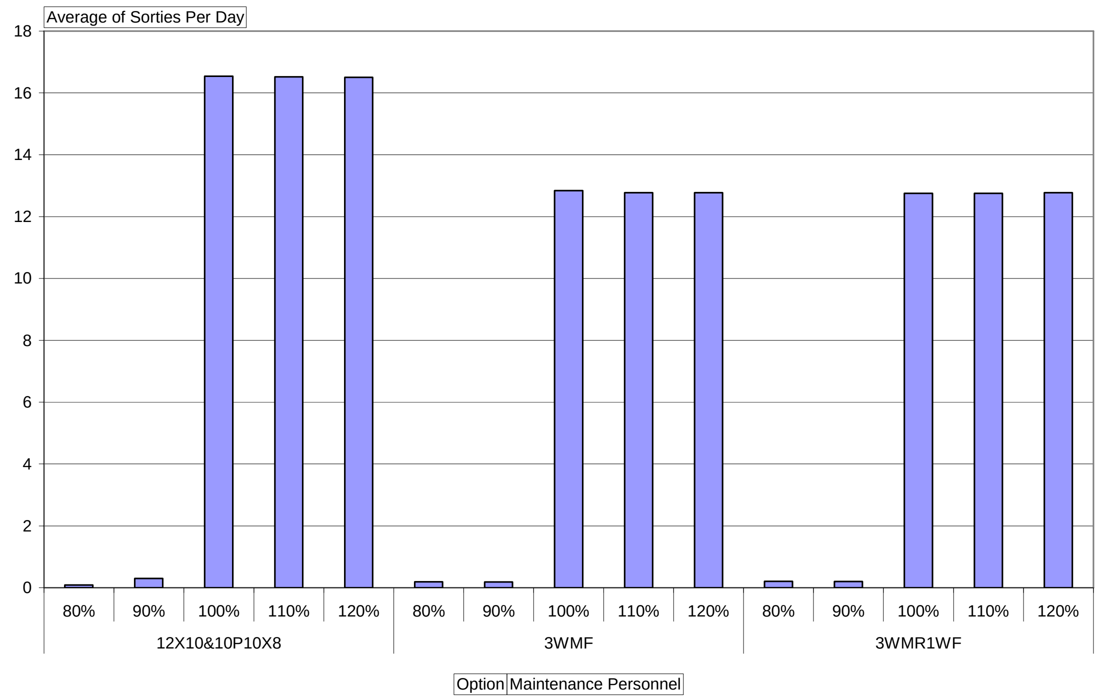


Figure 40. Inability to Produce Sorties with Reduction of Maintenance Personnel

This, of course, has a major impact on how Figure 38 is interpreted. Figure 41 is actually the same figure as Figure 38 but contains only current or increased manning options. Keeping in mind that personnel reduction leads to an inability to produce the required sorties per day, the simulation runs with reduced personnel were not incorporated in Figure 41. Now it seems that the 1-wave on Fridays scheduling option outperforms the other two options and is not affected by the personnel addition. The hot pit refueling option does not perform the as the other two options but it improves with increased manning levels.

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[16] A quick look at the simulation results reveals that engine personnel are marginally manned.

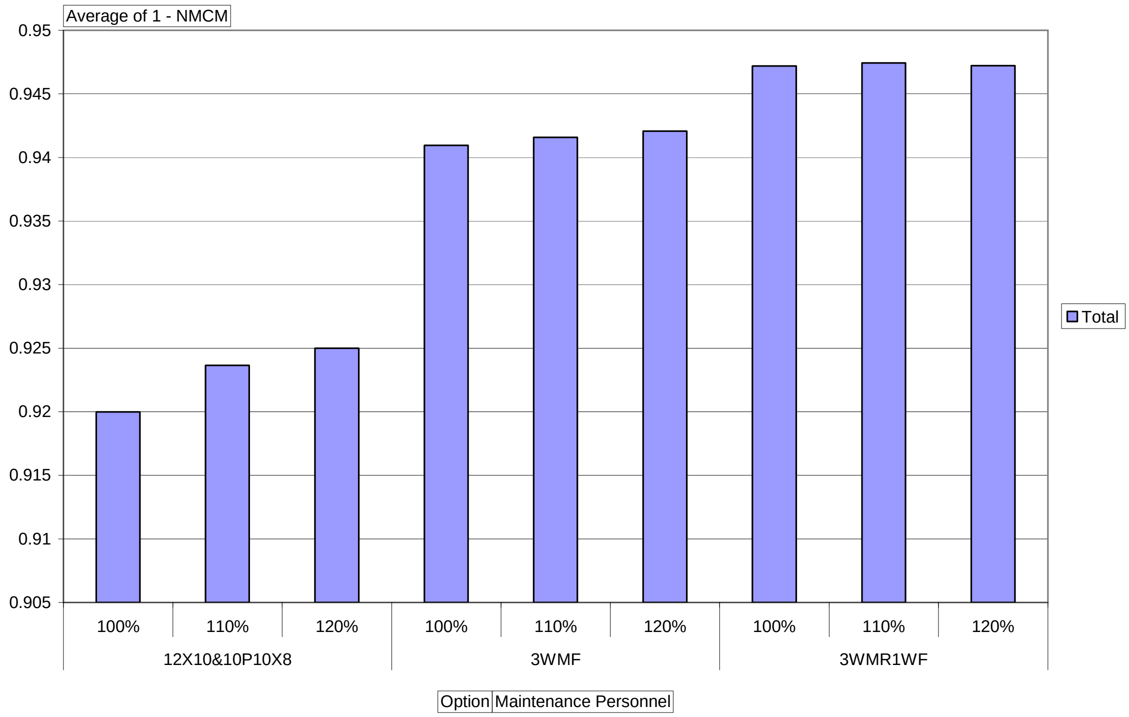


Figure 41. NMCM Rate Depending on Scheduling Philosophy without Decreasing Manning

The reason that the hot pit refueling scheduling option outperformed the other two options in Figure 38 is because it has better performance with reduced manning options (Figure 42), although the required sorties can not be produced (Figure 40). Concerning the balanced approach, it seems that it does not influence the fleet health regardless of which scheduling option is used (Figure 43). When various levels of sorties are applied (Figure 44) all the options except the hot pit refueling approach are negatively impacted with higher sortie rates. The 1 wave on Fridays approach seems to outperform the other two options at all maintenance personnel and sortie surge levels.

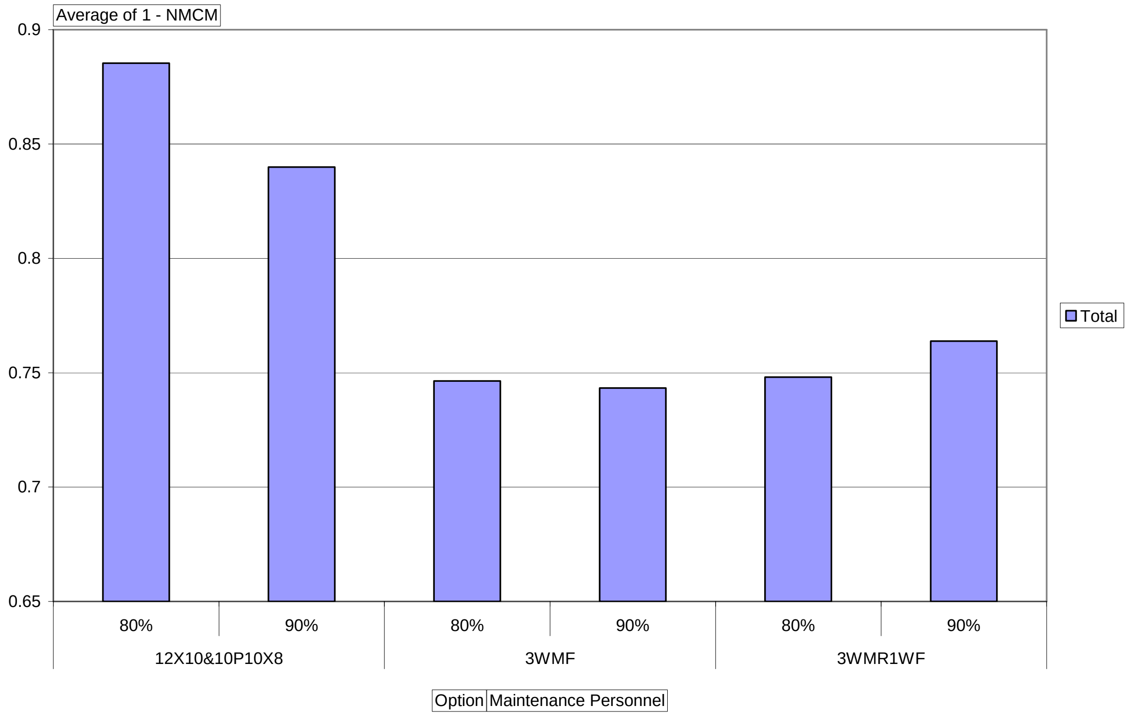


Figure 42. NMCM Rate Depending on Scheduling Philosophy with Decreased Manning

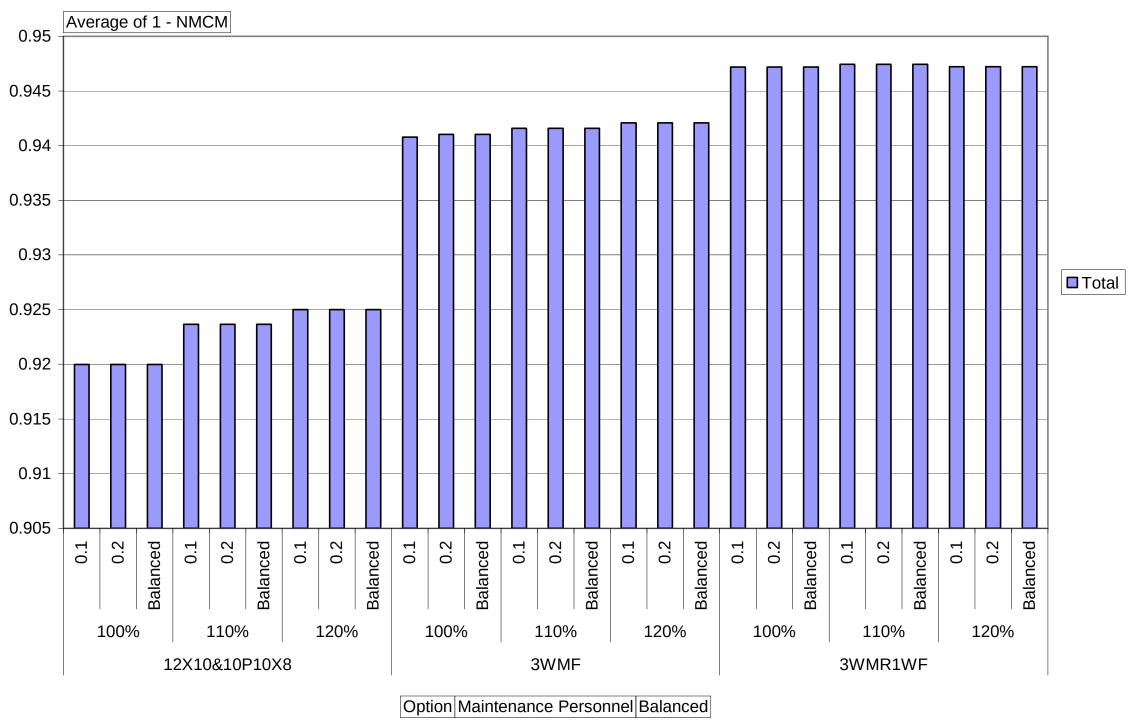


Figure 43. NMCM Rate Depending on Scheduling Philosophy and Balanced Schedule

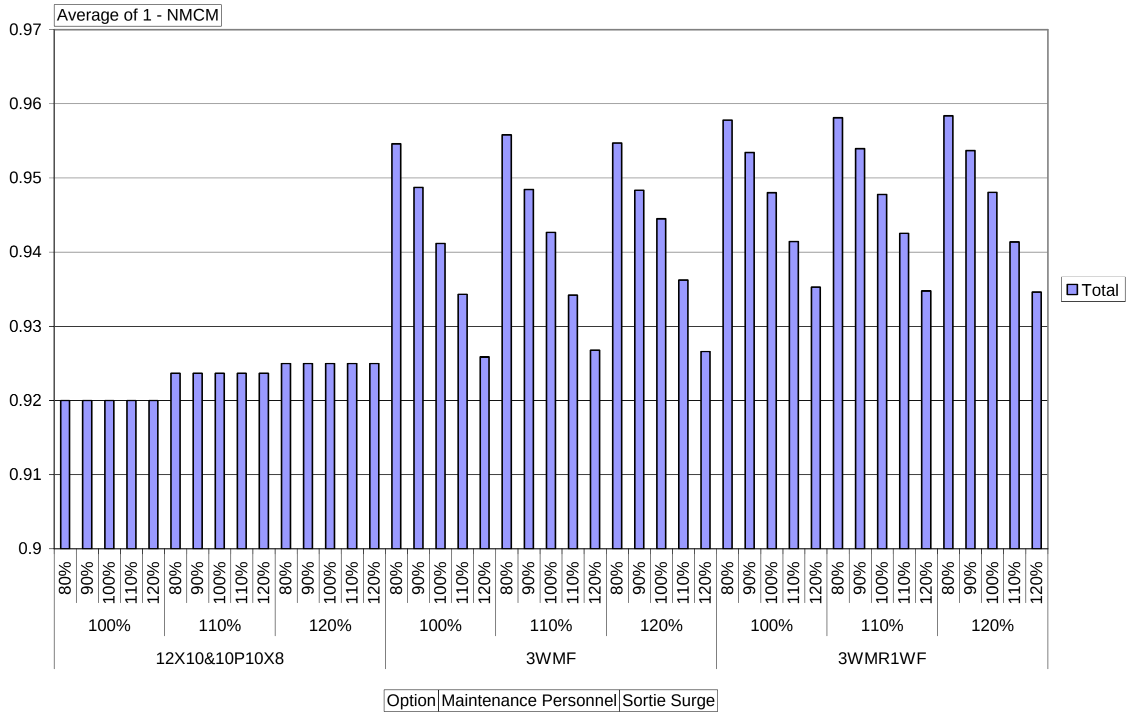


Figure 44. NMCM Rate Depending on Scheduling Philosophy and Sortie Surge

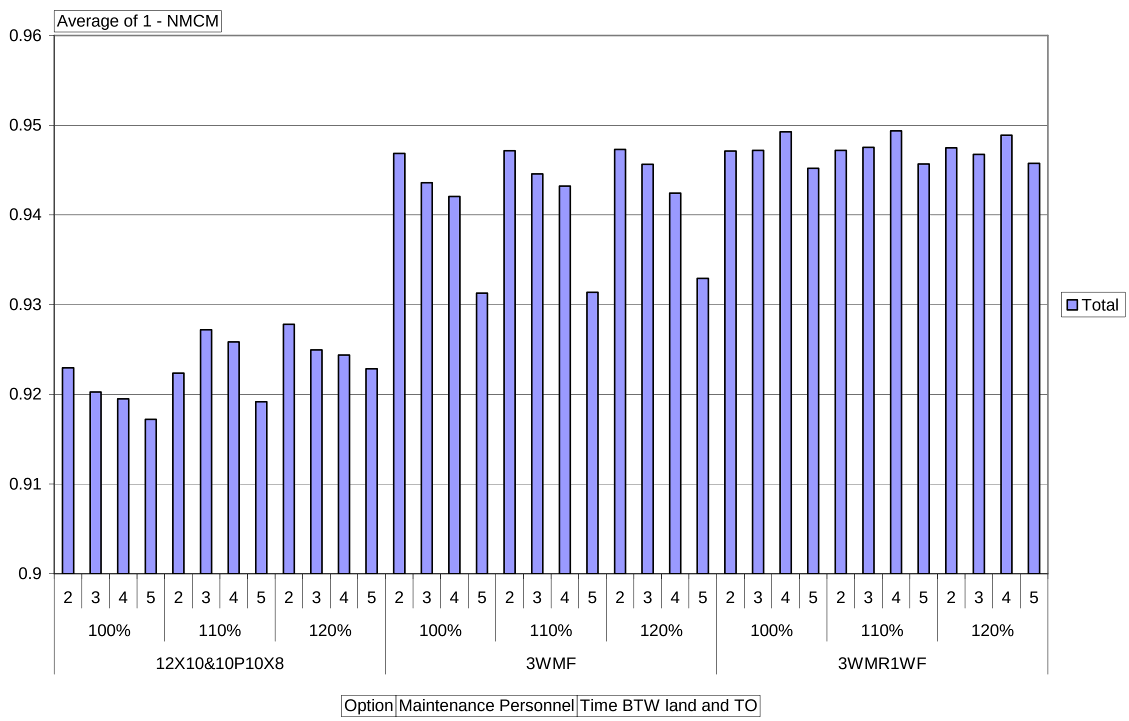


Figure 45. NMCM Rate Depending on Scheduling Philosophy and Time Between Landing and Take Off

Figure 45 shows how each scheduling option is affected by the time between landing and take off for various levels of maintenance personnel in terms of fleet health. The 3 waves Monday to Friday scheduling option is negatively impacted by increasing duration between landing and take-off at all manning levels. The 1 wave on Fridays approach seems to perform slightly better when there is enough time (4 hours) between landing and take-off while the optimum duration in the hot pit refueling approach depends on the manning level. However, an interesting finding is illustrated in Figure 46. If the maintenance personnel and the sortie rates are held constant at their current proposed levels, then the hot pit refueling approach is the least desirable approach in terms of the long term health of the fleet. If the 2-hour window between landing and take off is followed, there is no difference between the other two alternative scheduling options while the 1-wave on Fridays approach performs slightly better on longer flying windows regardless of how balanced the daily schedule is.

Maintenance Effectiveness.

The output variables of interest concerning maintenance effectiveness are the discrepancies awaiting maintenance (AWM), the average time in maintenance activity queues (ATQMA) and the flying window (lower value is better for these metrics). Figures 47, 48, and 49 show that regardless of the manning levels the 1 wave on Fridays scheduling option outperforms the other two alternatives. In addition, the rational result that the AWM, ATQMA, and Flying window are reduced with increased manning levels is shown.

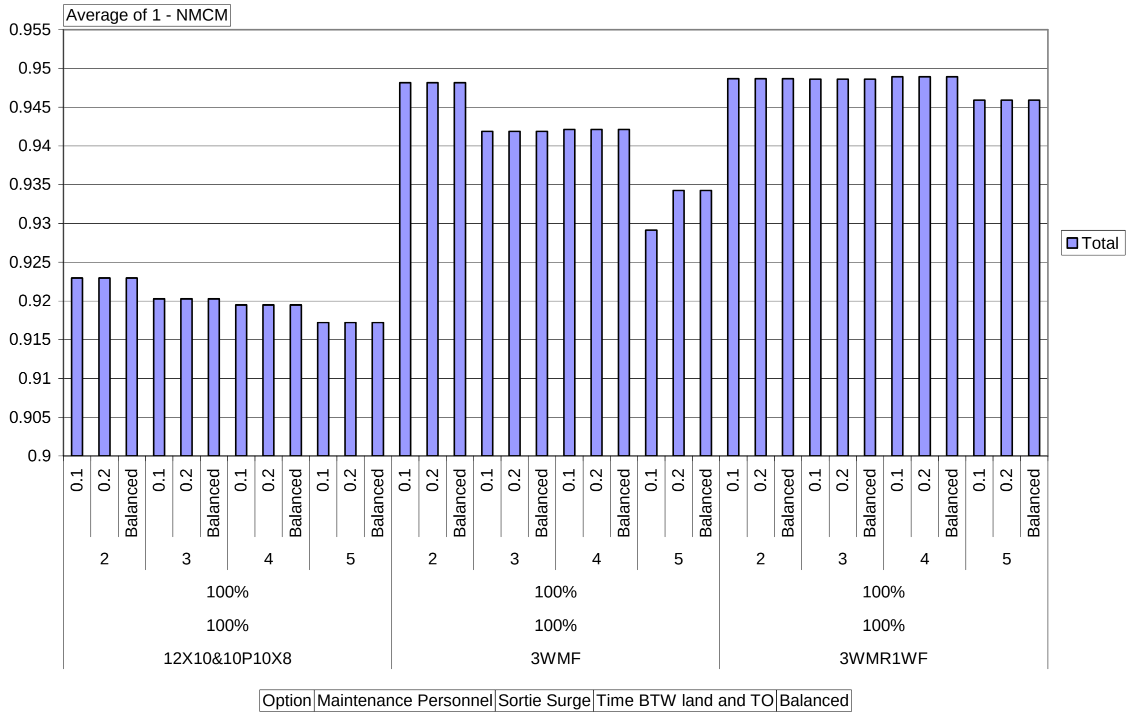


Figure 46. NMCM Rate Depending on Scheduling Philosophy - Time Between Landing and Take Off – Balanced

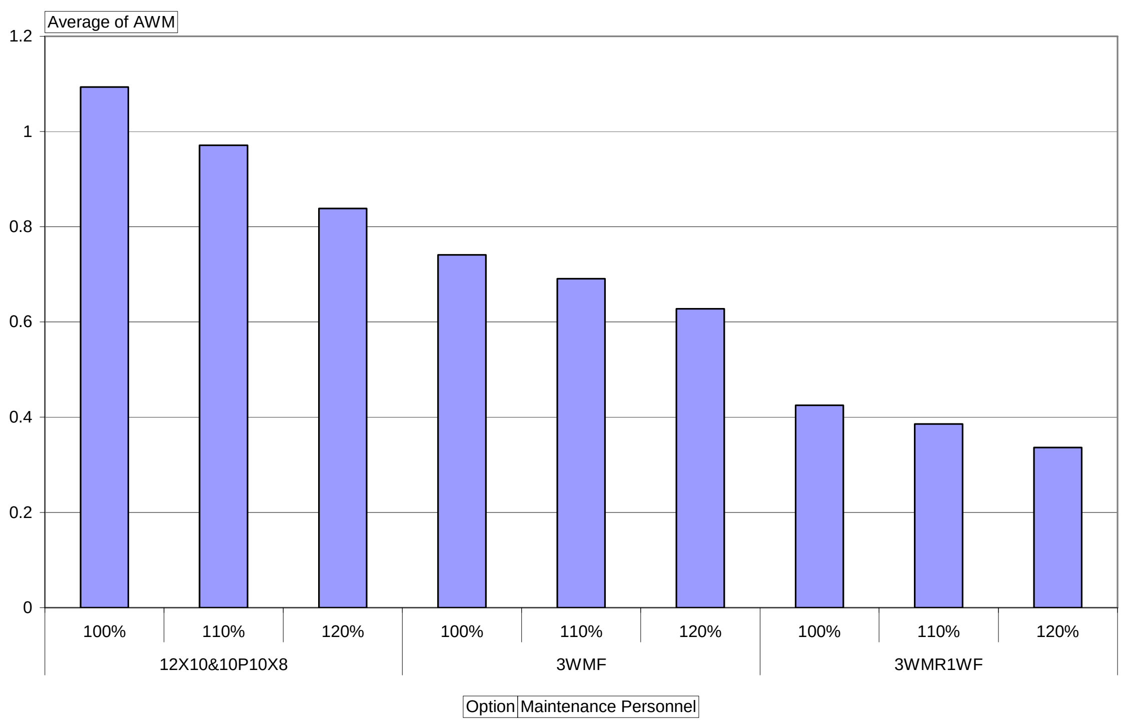


Figure 47. AWM Depending on Maintenance Option and Maintenance Personnel

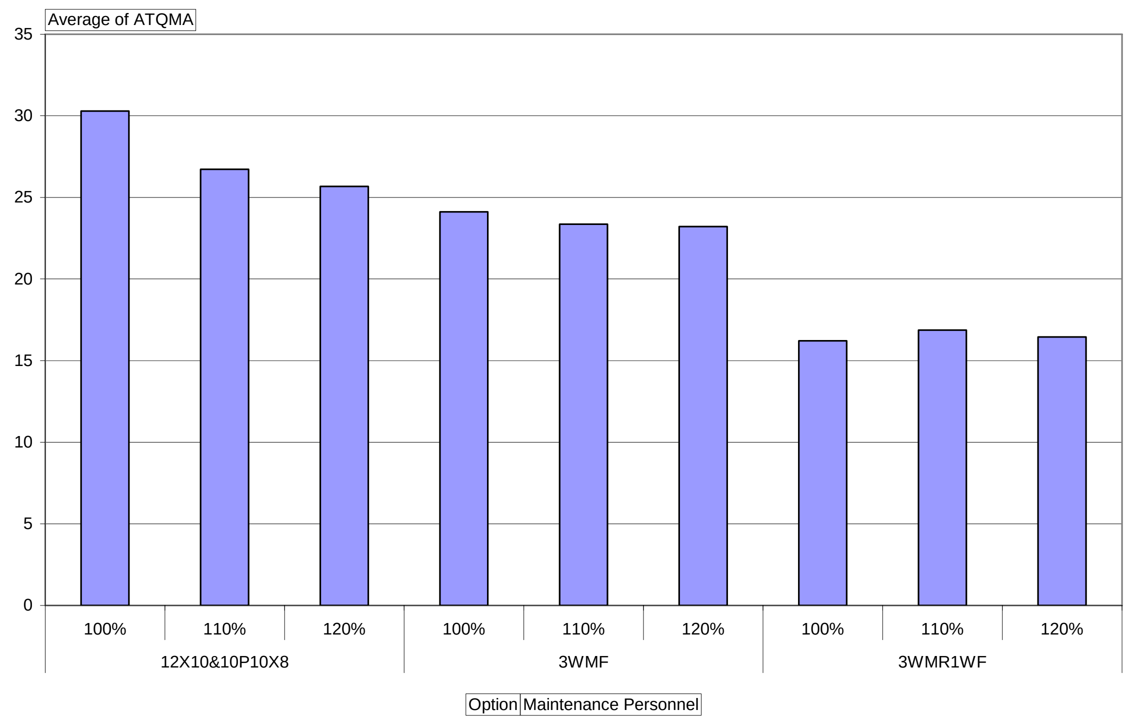


Figure 48. ATQMA Depending on Maintenance Option and Maintenance Personnel

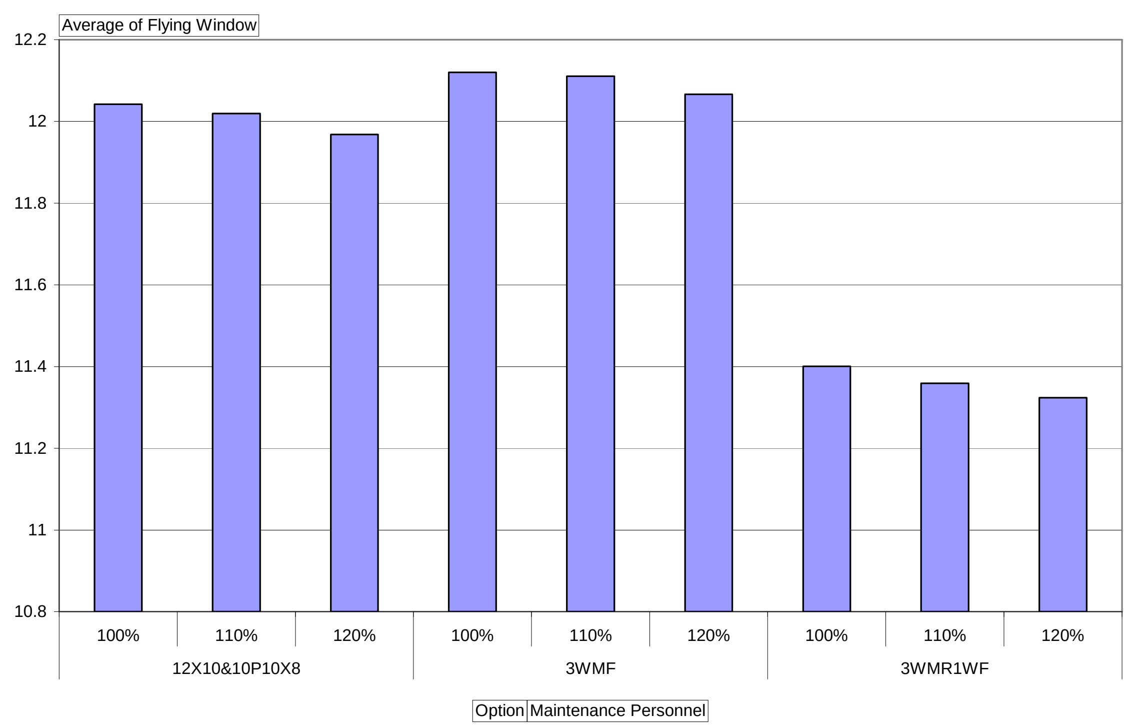


Figure 49. Flying Window Depending on Maintenance Option and Maintenance Personnel

Concerning the balanced approach, it seems that it does not influence the maintenance effectiveness in any of the outputs of interest (AWM, ATQMA, Flying Window) regardless of the manning level and the scheduling option (figures 50, 51, and 52). When various levels of sorties are applied (Figures 53, 54, and 55) all the options except the hot pit refueling approach are negatively impacted with higher sortie rates. The 1 wave on Fridays approach seems to outperform the other two options at all of the maintenance personnel and sortie surge levels. It is interesting to notice that with the same manning levels the 3-waves everyday scheduling option achieves the same maintenance effectiveness if the sorties are reduced by almost 20% compared to the 1-wave on Fridays option.

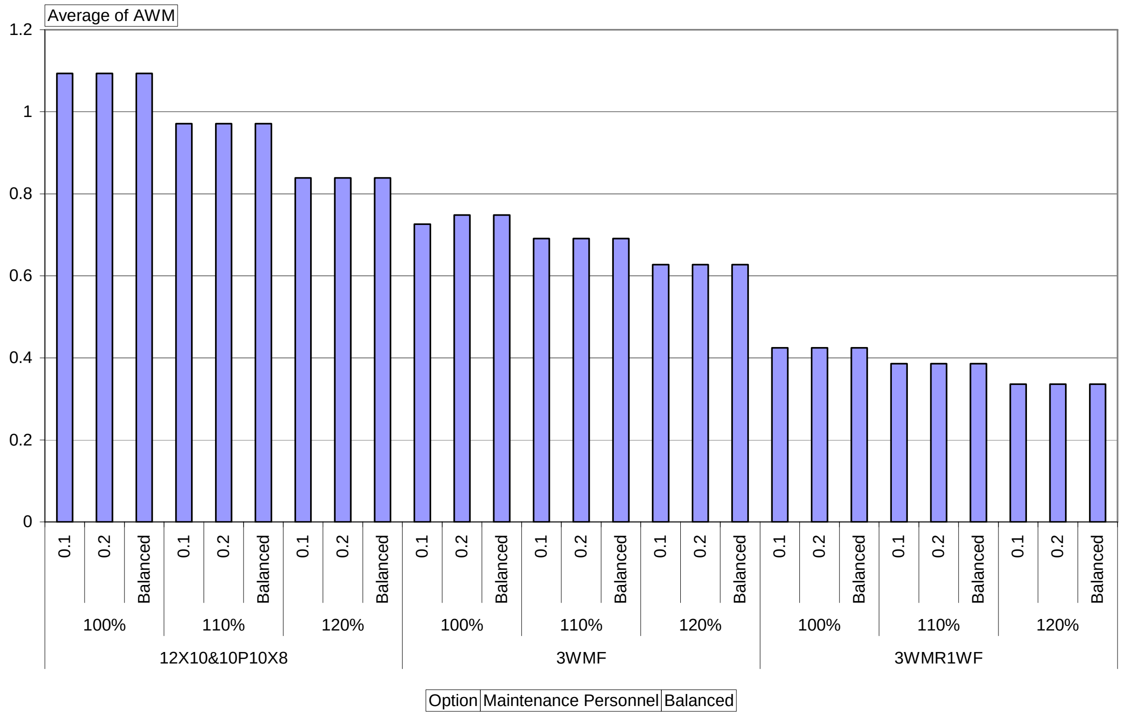


Figure 50. AWM Depending on Scheduling Philosophy and Balanced Schedule

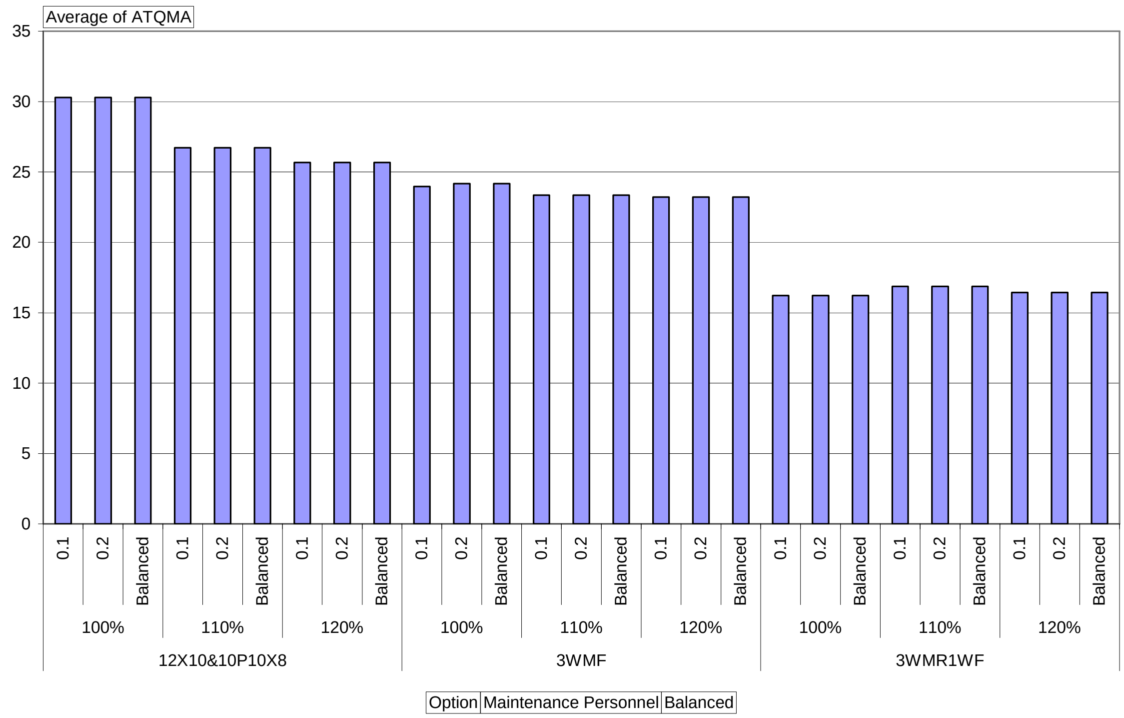


Figure 51. ATQMA Depending on Scheduling Philosophy and Balanced Schedule

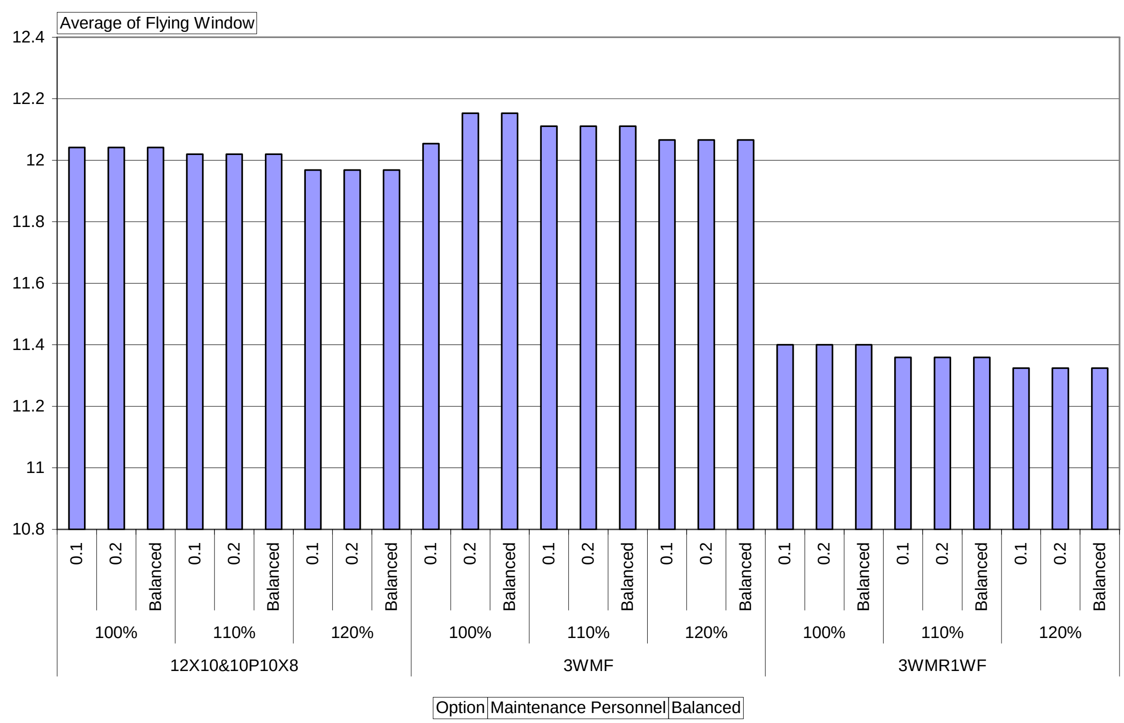


Figure 52. Flying Window Depending on Scheduling Philosophy and Balanced Schedule

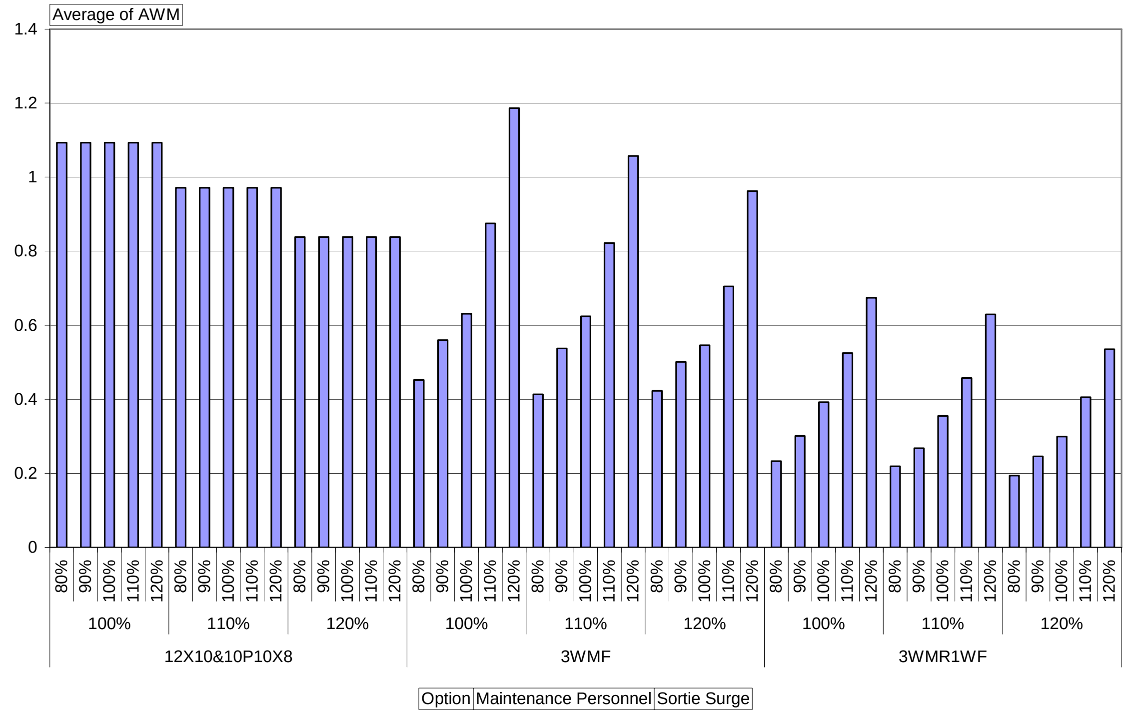


Figure 53. AWM Depending on Scheduling Philosophy and Sortie Surge

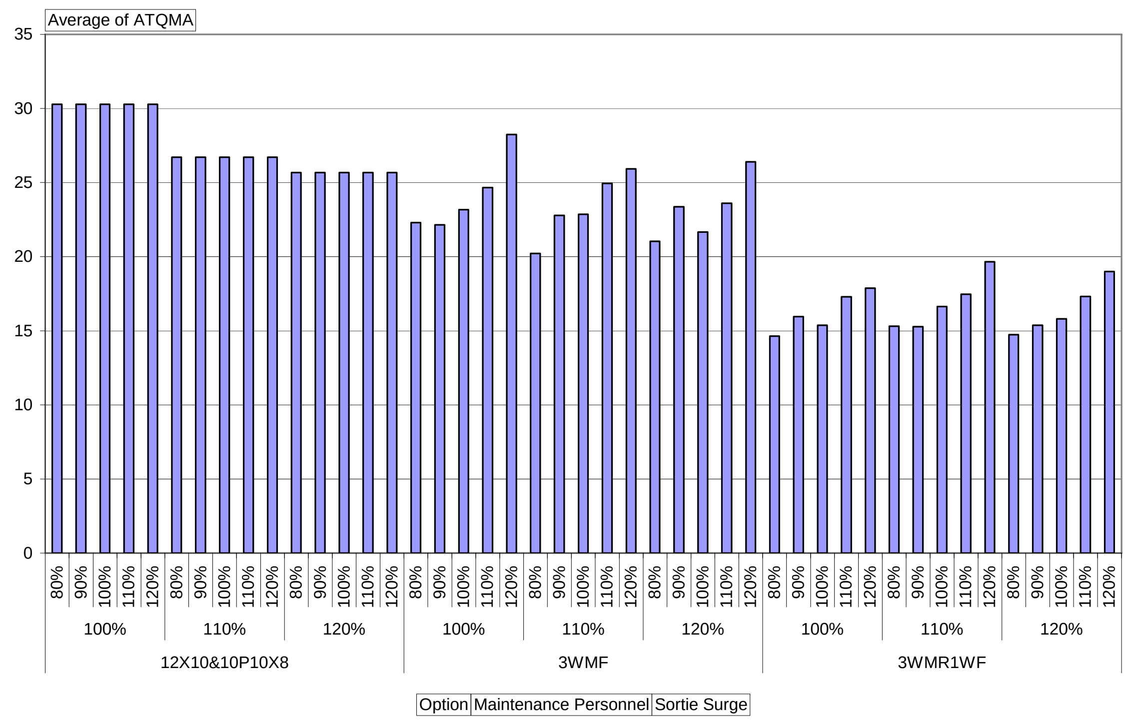


Figure 54. ATQMA Depending on Scheduling Philosophy and Sortie Surge

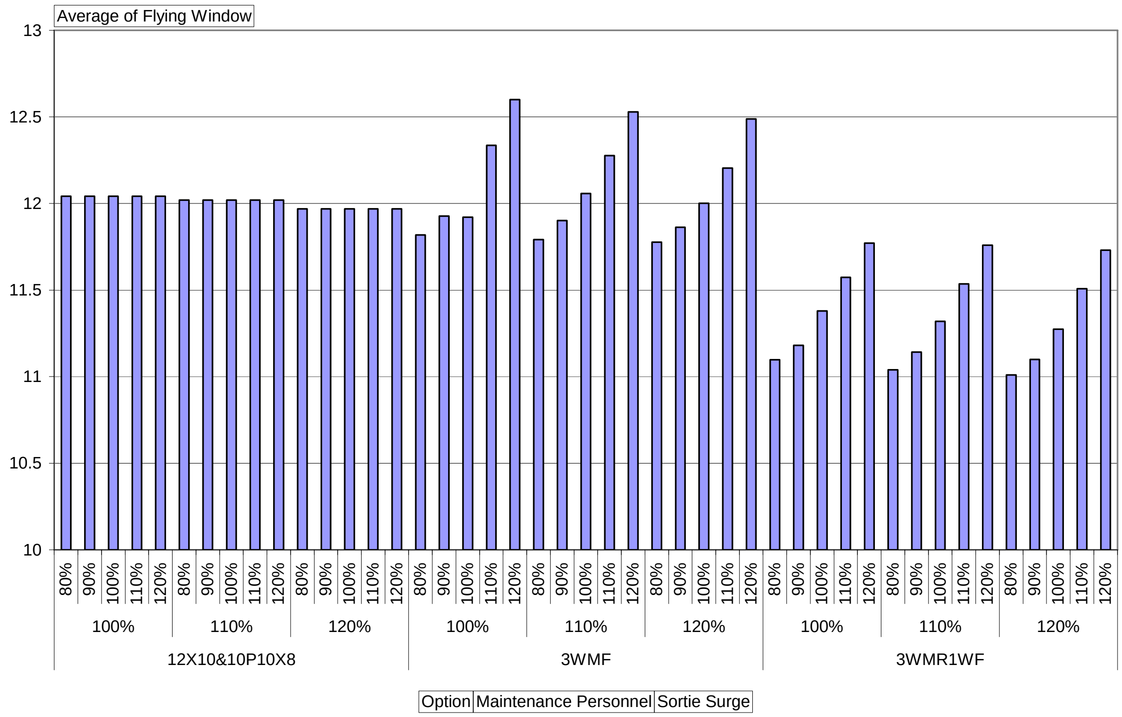


Figure 55. Flying Window Depending on Scheduling Philosophy and Sortie Surge

Figures 56, 57, and 58 show how each scheduling option is affected by the time between landing and take off for various levels of maintenance personnel in terms of maintenance effectiveness. The 3 waves Monday to Friday and the 1 wave on Fridays scheduling options are negatively impacted by increasing duration between landing and take-off at all manning levels. The optimum duration in the hot pit refueling approach depends on the manning level, and it varies from 2 to 4 hours depending on the output variable of interest. However, an interesting finding is illustrated in Figures 59, 60, and 61. If the maintenance personnel and the sortie rates are held constant at their current proposed levels, then the hot pit refueling approach tends to be the worst option in terms of the maintenance effectiveness, especially at the shortest durations between landing and take-off. It also seems that the 1 wave on Fridays approach not only outperforms the

other two alternatives for all output variables of interest, but it is also less sensitive to potential changes in the flying schedule stability (balanced approach) and in the duration between the landing and take-off[17].

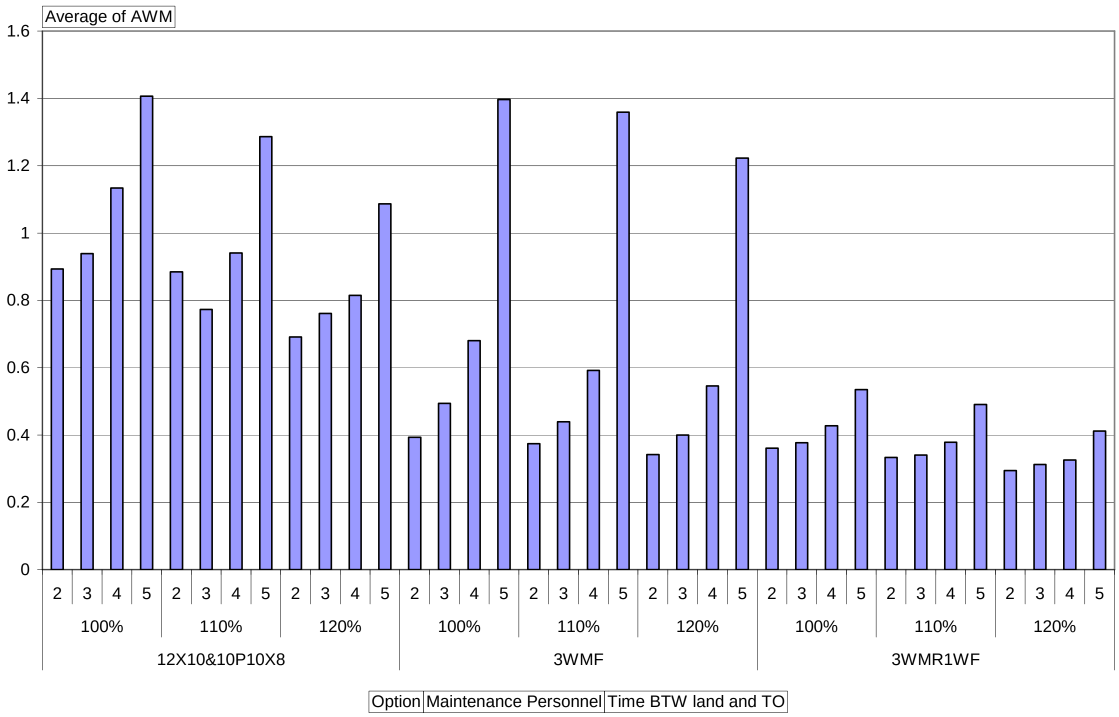


Figure 56. AWM Depending on Scheduling Philosophy and Time Between Landing and Take Off

[17] These parameters usually change in the Squadron environment and mainly depend on operational factors (flying schedule, range availability, crew rest etc).

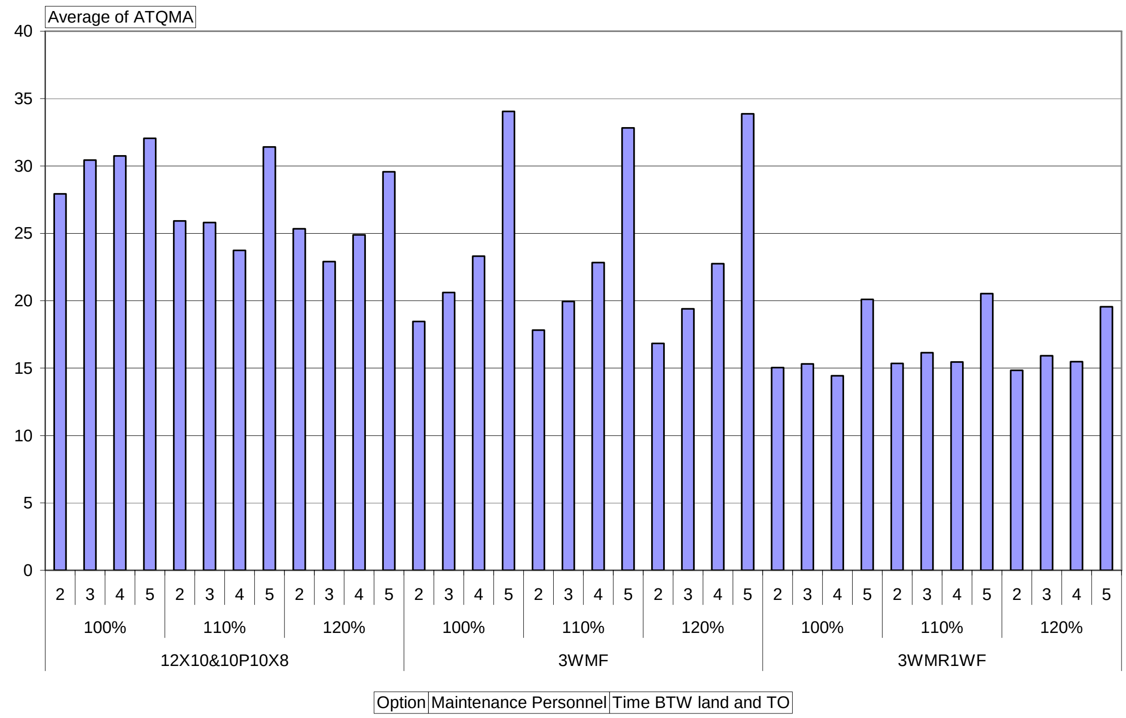


Figure 57. ATQMA Depending on Scheduling Philosophy and Time Between Landing and Take Off

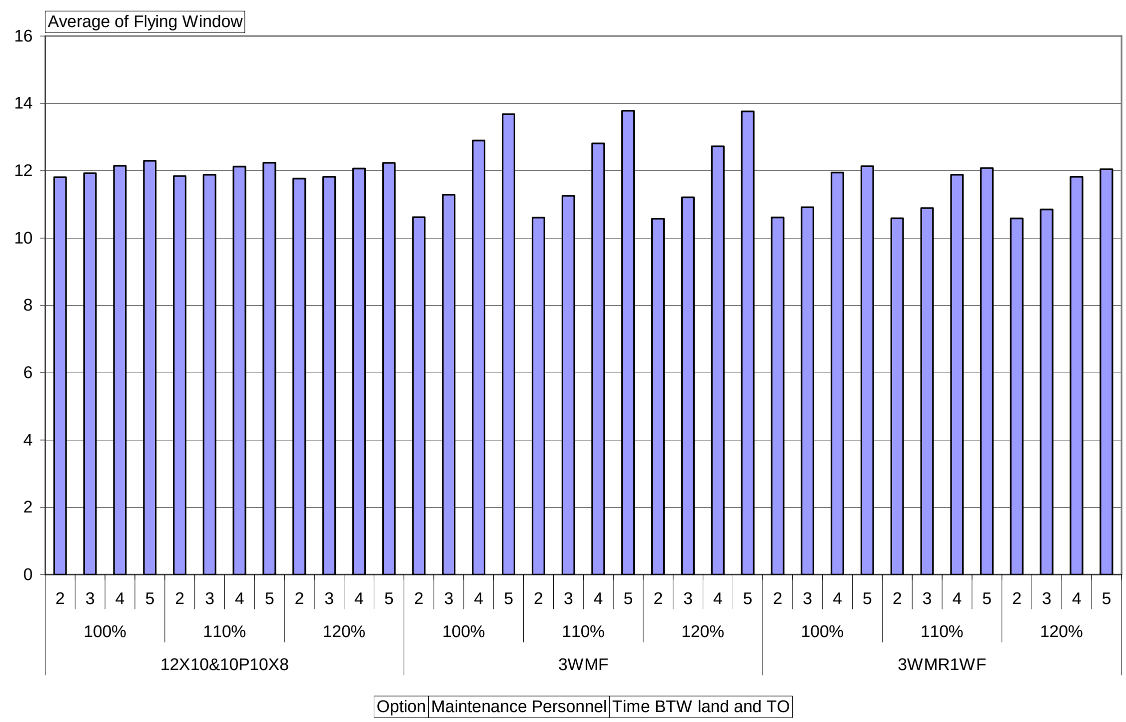


Figure 58. Flying Window Depending on Scheduling Philosophy and Time Between Landing and Take Off

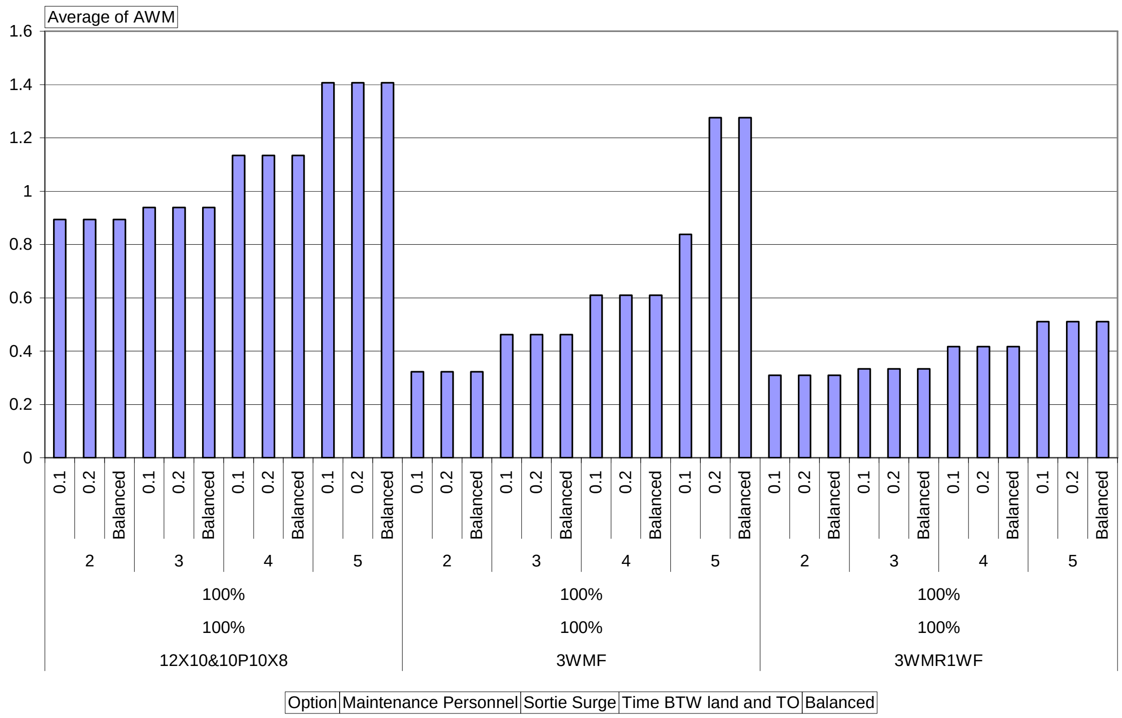


Figure 59. AWM Depending on Scheduling Philosophy - Time Between Landing and Take Off – Balanced

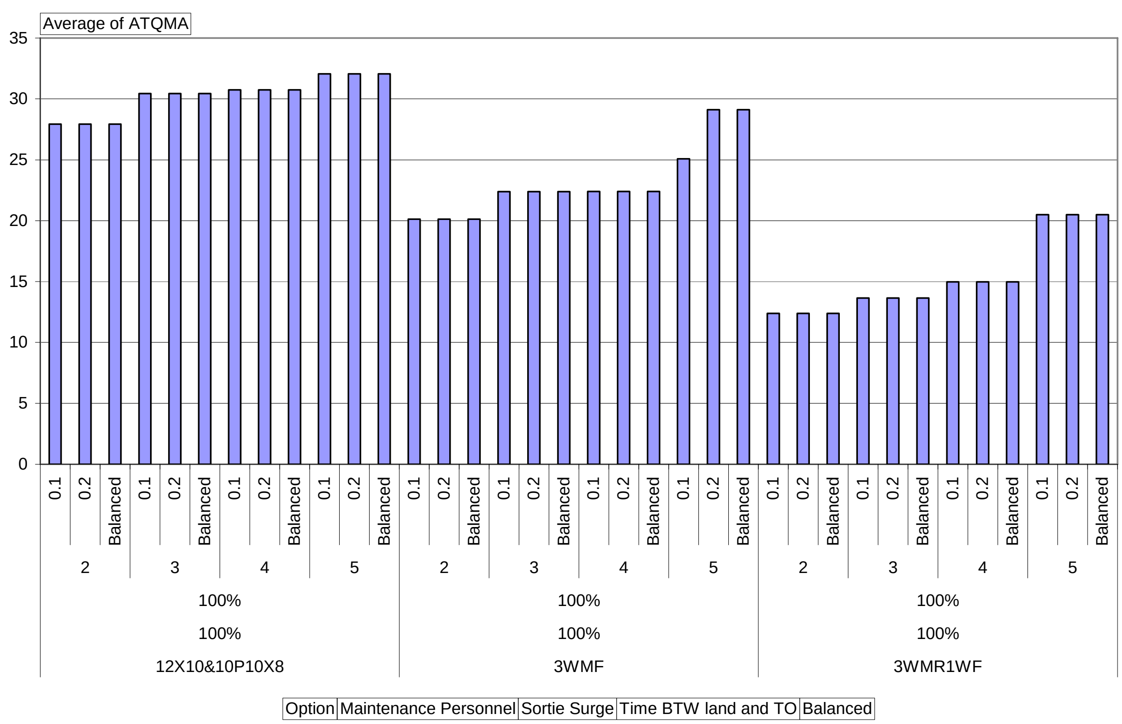


Figure 60. ATQMA Depending on Scheduling Philosophy - Time Between Landing and Take Off – Balanced

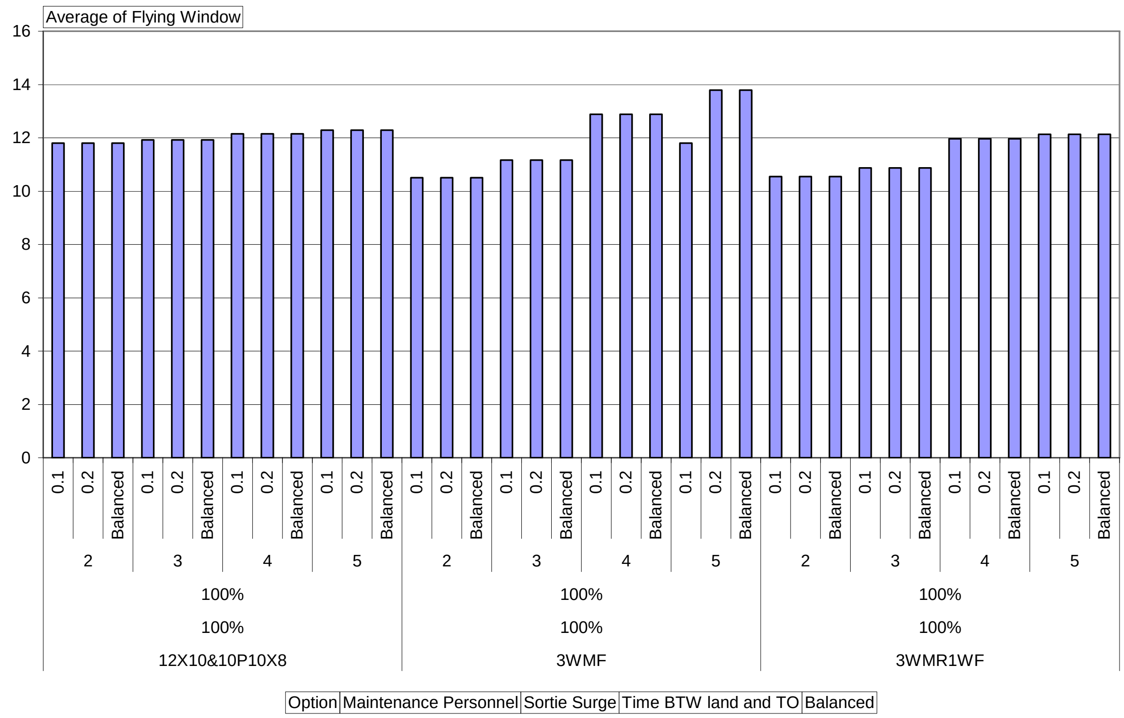


Figure 61. Flying Window Depending on Scheduling Philosophy - Time Between Landing and Take Off – Balanced

4th Investigative Question

Is there statistical evidence that one of the philosophies is better than the others and under what situations?

The sensitivity analysis of the previous paragraph identified that the balanced – unbalanced approach is not an influential factor for the purpose of this research. In addition, reduction of maintenance personnel causes an inability to produce the required sorties and further research is proposed to identify the bottlenecks in the sortie production process and the effect that different manning levels impose on the various maintenance scheduling philosophies. In addition, the 5-hour duration between landing and take-off produces the worst results and is not be examined any further.

The protocol of the designed experiment now takes the following format:

1. Maintenance scheduling philosophy with the following factor levels:
    a. 3 waves Monday to Friday
    b. 3 waves Monday to Thursday and 1 wave on Friday
    c. 12 turn 10 for 3 weeks and 10 hot pit 10 turn 8 for 1 week
2. Time between land and takeoff with four factor levels:
    a. 2 hours
    b. 3 hours
    c. 4 hours
3. Sorties Production Goal with five factor levels
    a. 20% decrease in proposed flying schedule per month
    b. 10% decrease in proposed flying schedule per month
    c. The proposed flying schedule itself
    d. 10% increase in proposed flying schedule per month
    e. 20% increase in proposed flying schedule per month

So, there are 45 total treatments (3 philosophies X 3 times between landing and take-off X 5 sortie surge levels). The output variables of interest are still the same: the NMCM Rate for the fleet health and the AWM, ATQMA, and Flying Window for the maintenance effectiveness.

Pilot Study.

A pilot study was conducted to determine the number of replications that should be performed. The model was run 270 times (6 times for each treatment X 45 treatments). The Fit Model is illustrated in Figure 62. All the output variables were entered into the

model. The three independent variables and the interactions between them were added in the model effects.

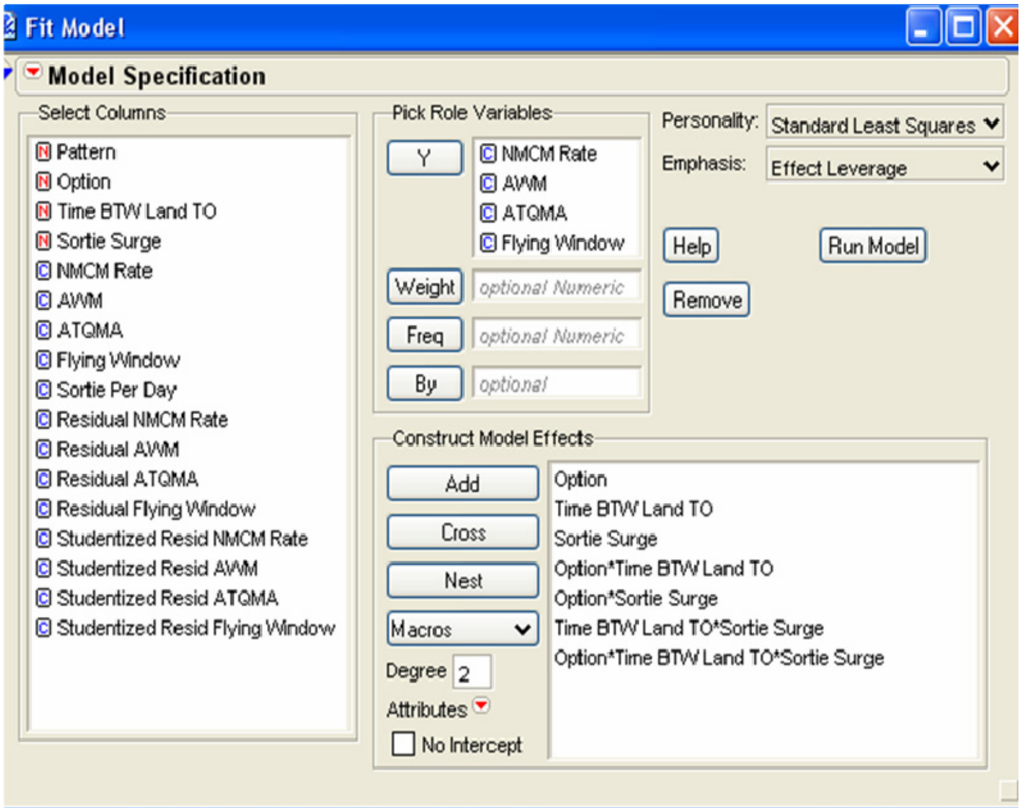


Figure 62. Fit Model for Pilot Study

The pilot study for NMCM Rate returned a coefficient of determination (R-square) 0.975 which represents the proportion of the total sample variability around the mean of NMCM Rate that is explained by the model relationship between NMCM Rate and the chosen model effects. In other words, about 97.5% of the sample variation in NMCM Rate (measured by the total sum of squares of deviations of the sample NMCM Rate values about their mean) can be explained by using the chosen model. In addition, the model fit returned a root mean square error of 0.00223 (Figure 63) which is the best estimate of standard deviation.

The power analysis feature of the software program JMP was used to determine the number of replicates of the experiment. In terms of the NMCM Rate response, the power details of the scheduling philosophy factor are illustrated in figure 64. This figure shows that even if the standard deviation is increased by ten times there is no need to increase the sample size in order to detect statistical significant difference between the various scheduling philosophies; the power of the test will be 1.0 so the Type II error β[18] is 0. Because the experiment checks also for interactions between the maintenance scheduling philosophy, the sortie surge levels, and the different levels of the time between landing and take-off, the power analysis was performed for the interactions also.

Summary of Fit	
RSquare	0.975965
RSquare Adj	0.971265
Root Mean Square Error	0.002234
Mean of Response	0.938571
Observations (or Sum Wgts)	270

Figure 63. Summary of Fit of Pilot Study for NMCM rate

In terms of the NMCM Rate, the statistical significant differences between the interaction levels of maintenance scheduling philosophies and the durations between landing and take-off can be detected with a power of 0.9799 with the same sample size and a tripled standard deviation. Similarly the power is 1.000 when the interaction between the maintenance philosophies and the sortie surge levels is analyzed (Figures 65, 66 respectively).

[18] The Type II error probability β is calculated assuming that the null hypothesis that all the treatment means are equal is false, because it is defined as the probability of accepting H_0 when it is false.

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.002234	0.010601	270	1.0000
0.0500	0.003234	0.010601	270	1.0000
0.0500	0.004234	0.010601	270	1.0000
0.0500	0.005234	0.010601	270	1.0000
0.0500	0.006234	0.010601	270	1.0000
0.0500	0.007234	0.010601	270	1.0000
0.0500	0.008234	0.010601	270	1.0000
0.0500	0.009234	0.010601	270	1.0000
0.0500	0.010234	0.010601	270	1.0000
0.0500	0.011234	0.010601	270	1.0000
0.0500	0.012234	0.010601	270	1.0000
0.0500	0.013234	0.010601	270	1.0000
0.0500	0.014234	0.010601	270	1.0000
0.0500	0.015234	0.010601	270	1.0000
0.0500	0.016234	0.010601	270	1.0000
0.0500	0.017234	0.010601	270	1.0000
0.0500	0.018234	0.010601	270	1.0000
0.0500	0.019234	0.010601	270	1.0000
0.0500	0.020234	0.010601	270	1.0000
0.0500	0.021234	0.010601	270	1.0000
0.0500	0.022234	0.010601	270	1.0000

Figure 64. Power Details for Scheduling Philosophies for NMCM Rate

Power Details

Test Option*Time BTW Land TO

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.002234	0.001234	270	1.0000
0.0500	0.003234	0.001234	270	0.9997
0.0500	0.004234	0.001234	270	0.9799

Figure 65. Power Details for Interaction between Option and Time BTW Land TO for NMCM Rate

Power Details

Test Option*Sortie Surge

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.002234	0.0043	270	1.0000
0.0500	0.003234	0.0043	270	1.0000
0.0500	0.004234	0.0043	270	1.0000

Figure 66. Power Details for Interaction between Option and Sortie Surge for NMCM Rate

Generally, in terms of the NMCM Rate, there is no need for more than 6 replications in order to detect with Type I and Type II error of 0.05 statistical significant differences between the various treatment levels.

The same analysis was conducted for the other output variables of interest. AWM results are illustrated in figures 67-70, ATQMA results are illustrated in figures 71-74, and flying window results are illustrated in figures 75-78.

Summary of Fit

RSquare	0.998236
RSquare Adj	0.997891
Root Mean Square Error	0.01416
Mean of Response	0.634788
Observations (or Sum Wgts)	270

Figure 67. Summary of Fit of Pilot Study for AWM

Power Details

Test Option

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.01416	0.248843	270	1.0000
0.0500	0.02416	0.248843	270	1.0000
0.0500	0.03416	0.248843	270	1.0000
0.0500	0.04416	0.248843	270	1.0000

Figure 68. Power Details for Scheduling Philosophies for AWM

Power Details

Test Option*Time BTW Land TO

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.01416	0.038236	270	1.0000
0.0500	0.02416	0.038236	270	1.0000
0.0500	0.03416	0.038236	270	1.0000
0.0500	0.04416	0.038236	270	1.0000

Figure 69. Power Details for Interaction between Option and Time BTW Land TO for AWM

Power Details

Test Option*Sortie Surge

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.01416	0.093342	270	1.0000
0.0500	0.02416	0.093342	270	1.0000
0.0500	0.03416	0.093342	270	1.0000
0.0500	0.04416	0.093342	270	1.0000

Figure 70. Power Details for Interaction between Option and Sortie Surge for AWM

Summary of Fit

RSquare	0.981107
RSquare Adj	0.977413
Root Mean Square Error	0.910353
Mean of Response	21.88347
Observations (or Sum Wgts)	270

Figure 71. Summary of Fit of Pilot Study for ATQMA

Power Details

Test Option

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.910353	5.525159	270	1.0000
0.0500	1.910353	5.525159	270	1.0000
0.0500	2.910353	5.525159	270	1.0000
0.0500	3.910353	5.525159	270	1.0000

Figure 72. Power Details for Scheduling Philosophies for ATQMA

Power Details

Test Option*Time BTW Land TO

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.910353	0.890806	270	1.0000
0.0500	1.910353	0.890806	270	1.0000
0.0500	2.910353	0.890806	270	0.9887

Figure 73. Power Details for Interaction between Option and Time BTW Land TO for ATQMA

Power Details

Test Option*Sortie Surge

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.910353	1.03965	270	1.0000
0.0500	1.910353	1.03965	270	1.0000
0.0500	2.910353	1.03965	270	0.9949

Figure 74. Power Details for Interaction between Option and Sortie Surge for ATQMA

Summary of Fit

RSquare	0.998871
RSquare Adj	0.998651
Root Mean Square Error	0.029034
Mean of Response	11.56108
Observations (or Sum Wgts)	270

Figure 75. Summary of Fit of Pilot Study for Flying Window

Power Details

Test Option

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.029034	0.335208	270	1.0000
0.0500	0.049034	0.335208	270	1.0000
0.0500	0.069034	0.335208	270	1.0000

Figure 76. Power Details for Scheduling Philosophies for Flying Window

Power Details

Test Option*Time BTW Land TO

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.029034	0.339531	270	1.0000
0.0500	0.049034	0.339531	270	1.0000
0.0500	0.069034	0.339531	270	1.0000

Figure 77. Power Details for Interaction between Option and Time BTW Land TO for Flying Window

Power Details

Test Option*Sortie Surge

Power

Alpha	Sigma	Delta	Number	Power
0.0500	0.029034	0.156623	270	1.0000
0.0500	0.049034	0.156623	270	1.0000
0.0500	0.069034	0.156623	270	1.0000

Figure 78. Power Details for Interaction between Option and Sortie Surge for Flying Window

Generally, in terms of all the output variables, there is no need for more than 6 replications in order to detect with Type I and Type II error of 0.05 statistical significant differences between the various treatment levels even if the standard deviation doubles at least.

Assumptions.

In order for the designed experiment to be valid, the following three assumptions have been made:

Independent Samples.

Random independent samples from the respective populations are assumed to be present based on the inherent random characteristic of the simulation model by using independent separate number streams.

Normal Probability Distributions.

For checking the normality assumption, stem and leaf, and normal quantile plots were produced for each of the 45 treatments and 4 output variables. All these plots are illustrated in Appendix “S”. These 180 plots (45 treatments X 4 output variables) indicate that we do not have sufficient evidence to reject the normality assumption. So, all 45 population probability distributions of the treatments can be assumed to be normal. Keeping in mind also that small departures from normality do not create any serious

problems in the results, the normality assumption should not be of any concern for this experiment (Neter et al, 1996).

Normal probability plots of the residuals for all output variables were also prepared (figures 79-82). The points in these plot a moderately linear pattern. Normality of the error terms is supported by the high coefficient of correlation between the ordered residuals and their expected values under normality, namely 0.9427 for NMCM Rate, 0.9891 for AWM, 0.9724 for ATQMA, and 0.9899 for flying window. The expected values of the ordered residuals under normality are calculated based on the facts that the expected value of the error terms is zero and the standard deviation of the error terms is estimated by $\sqrt{MSE}$. Statistical theory has showsn that for a normal random variable with mean 0 and estimated standard deviation of $\sqrt{MSE}$, a good approximation of the expected *k*th smallest observation in a random sample of *n* is $\sqrt{MSE\left[z\left(\frac{k-.375}{n+.25}\right)\right]}$ (Neter et al, 1996).

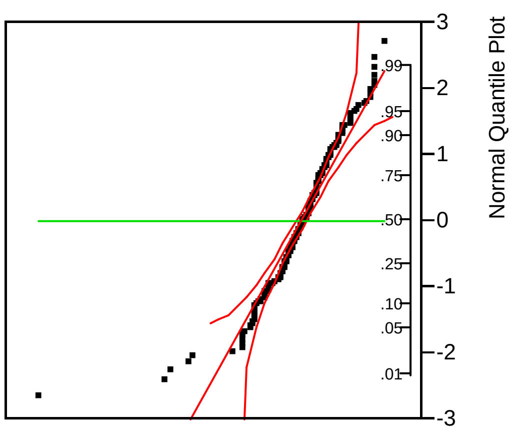


Figure 79. Normal Probability Plot of the Residuals (NMCM Rate)

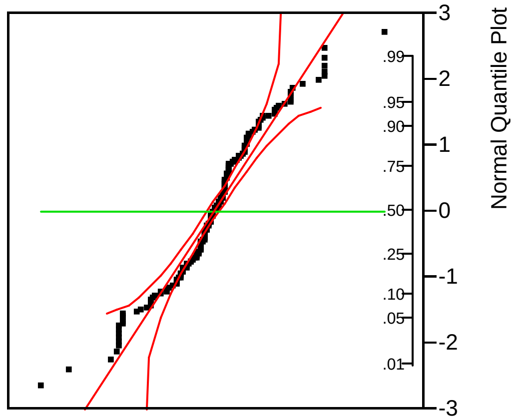


Figure 80. Normal Probability Plot of the Residuals (AWM)

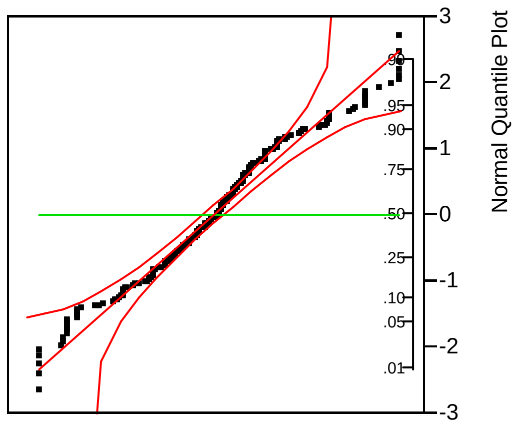


Figure 81. Normal Probability Plot of the Residuals (ATQMA)

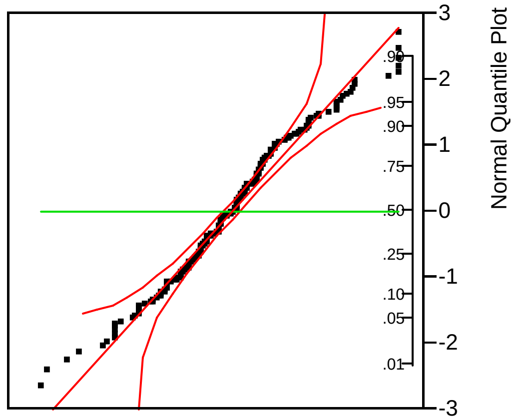


Figure 82. Normal Probability Plot of the Residuals (Flying Window)

Equal Variances - Homoscedasticity.

The homoscedasticity assumption was tested for all 4 output variables. For each output variable, a residual by predicted plot and a dotplot were created. The NMCS Rate plots are illustrated in figures 83-84, the AWM plots in figures 85-86, the ATQMA plots in figures 87-88, and the flying window plots in figures 89-90. All the AWM residual by predicted plots indicate that there is no evidence of unequal error variances for the different treatments. All eight figures (83-90) indicate model appropriateness in terms of equal variances across the treatments.

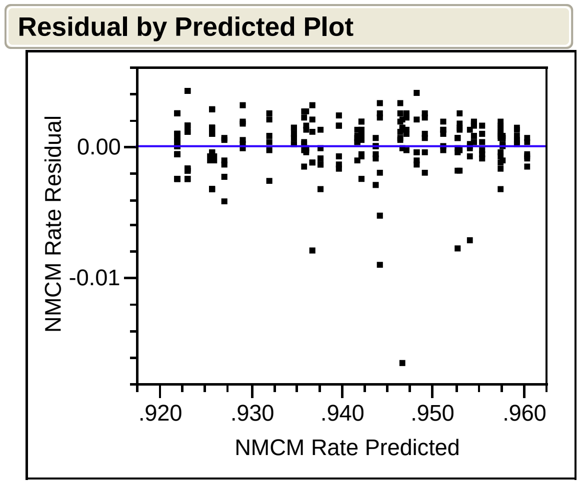


Figure 83. NMCM Rate Residual by Predicted Plot

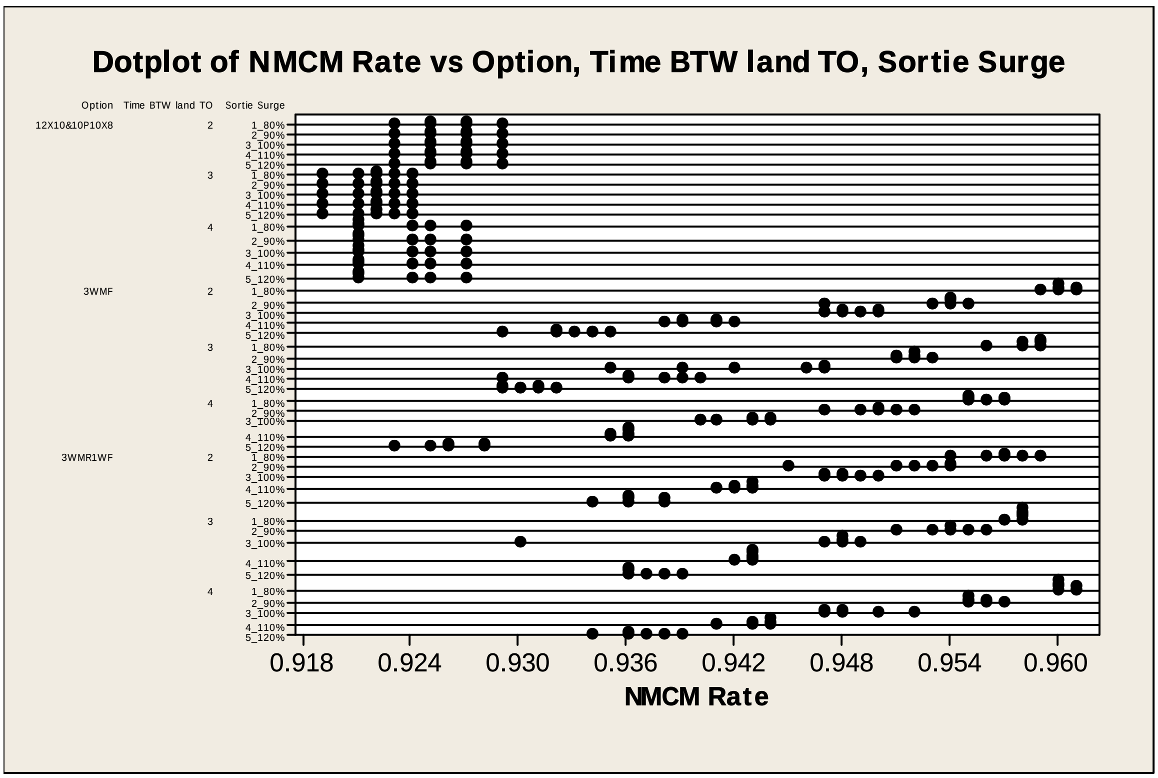


Figure 84. NMCM Rate Dot-Plot

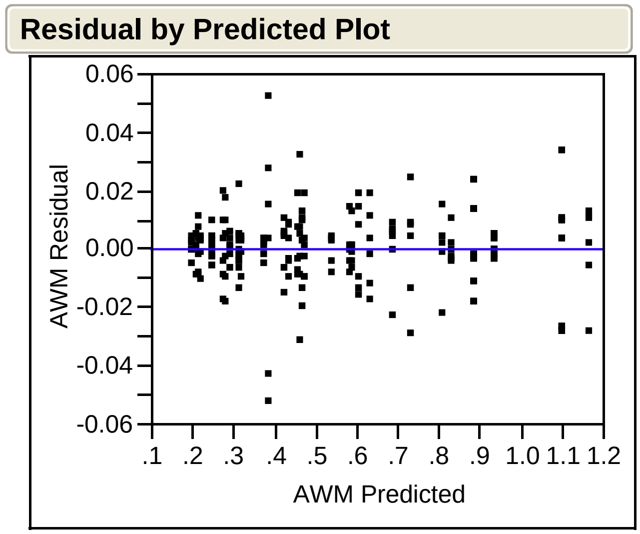


Figure 85. AWM Residual by Predicted Plot

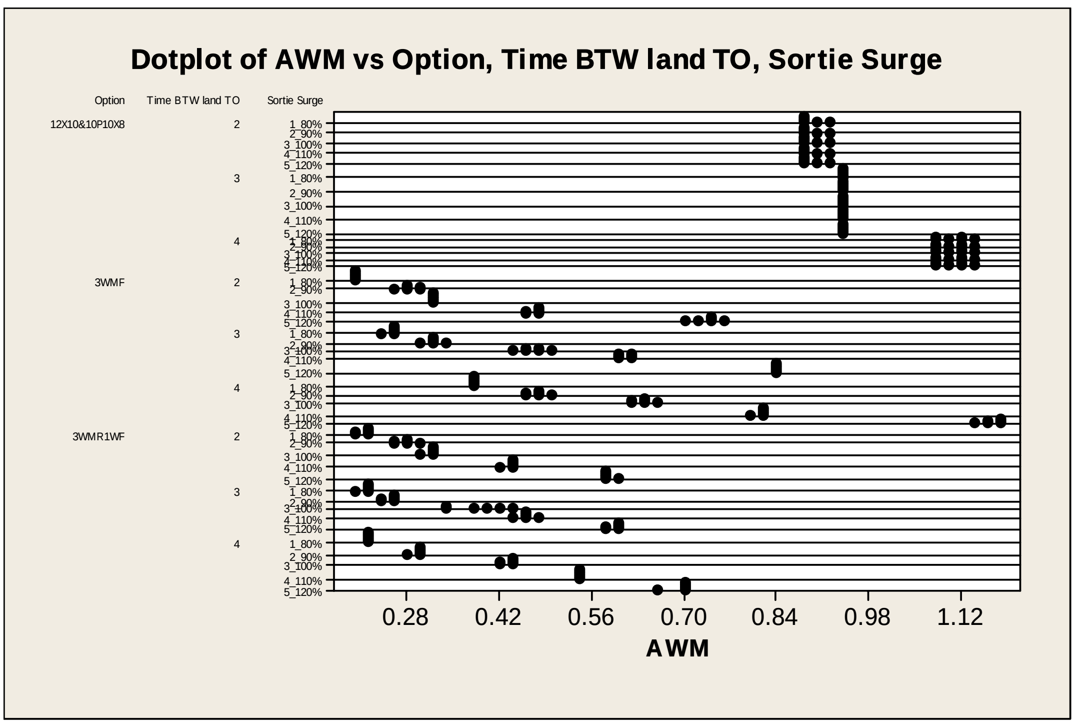


Figure 86. AWM Dot-Plot

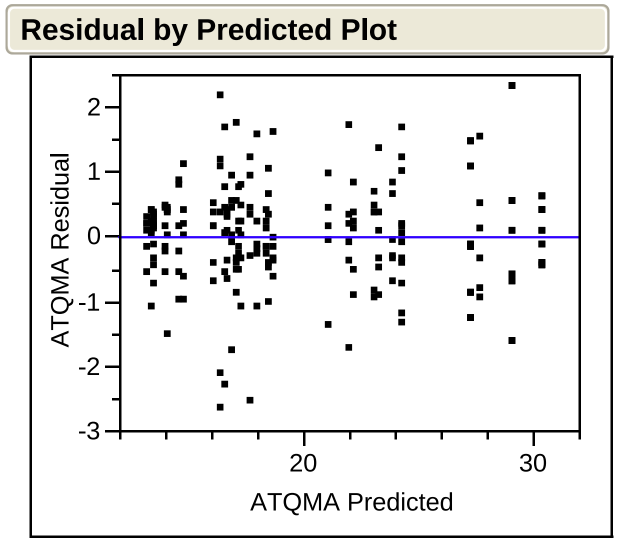


Figure 87. ATQMA Residual by Predicted Plot

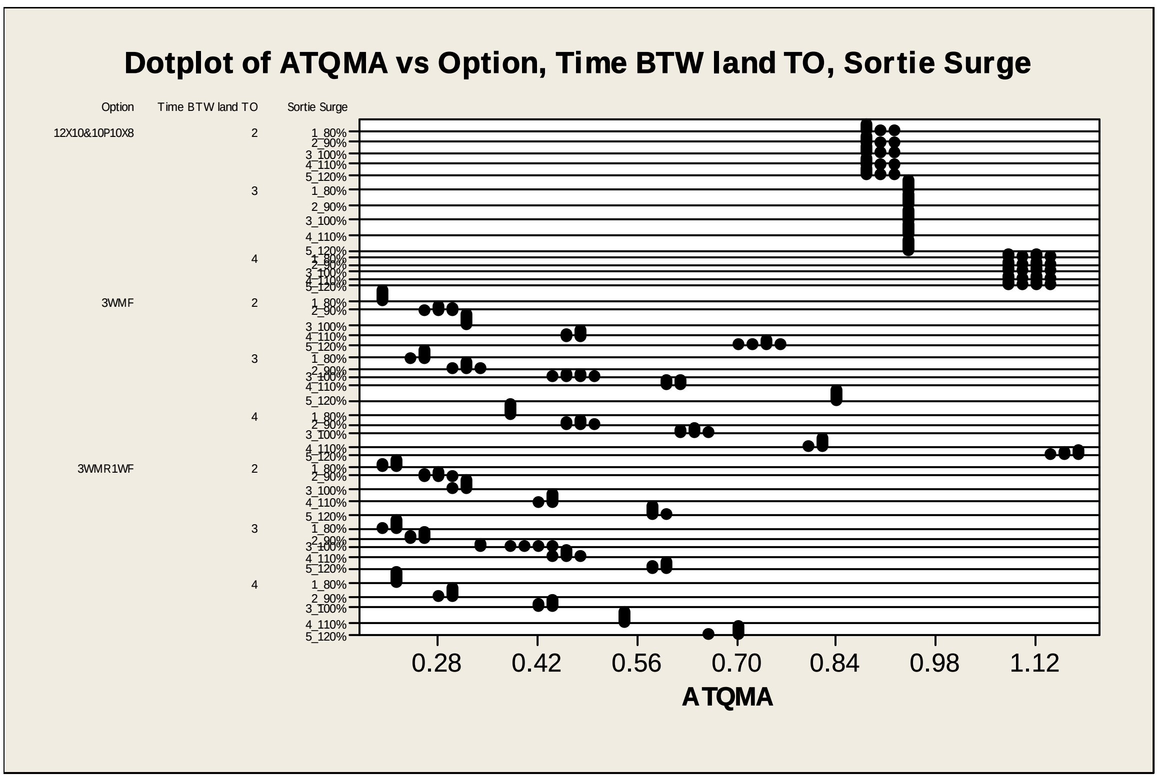


Figure 88. ATQMA Dot-Plot

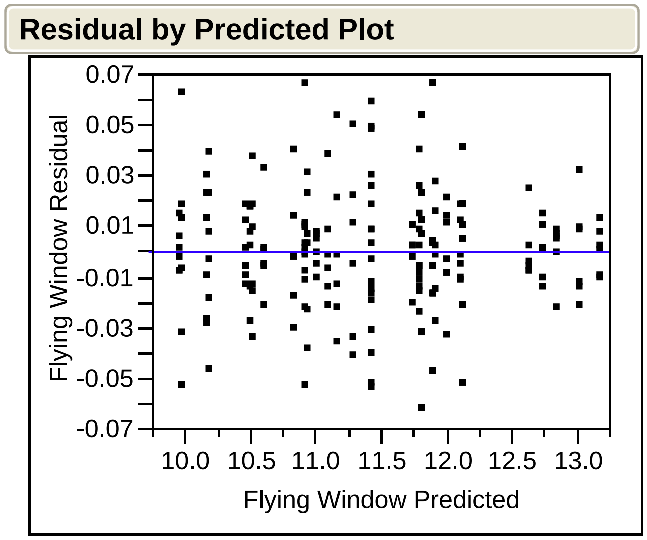


Figure 89. Flying Window Residual by Predicted Plot

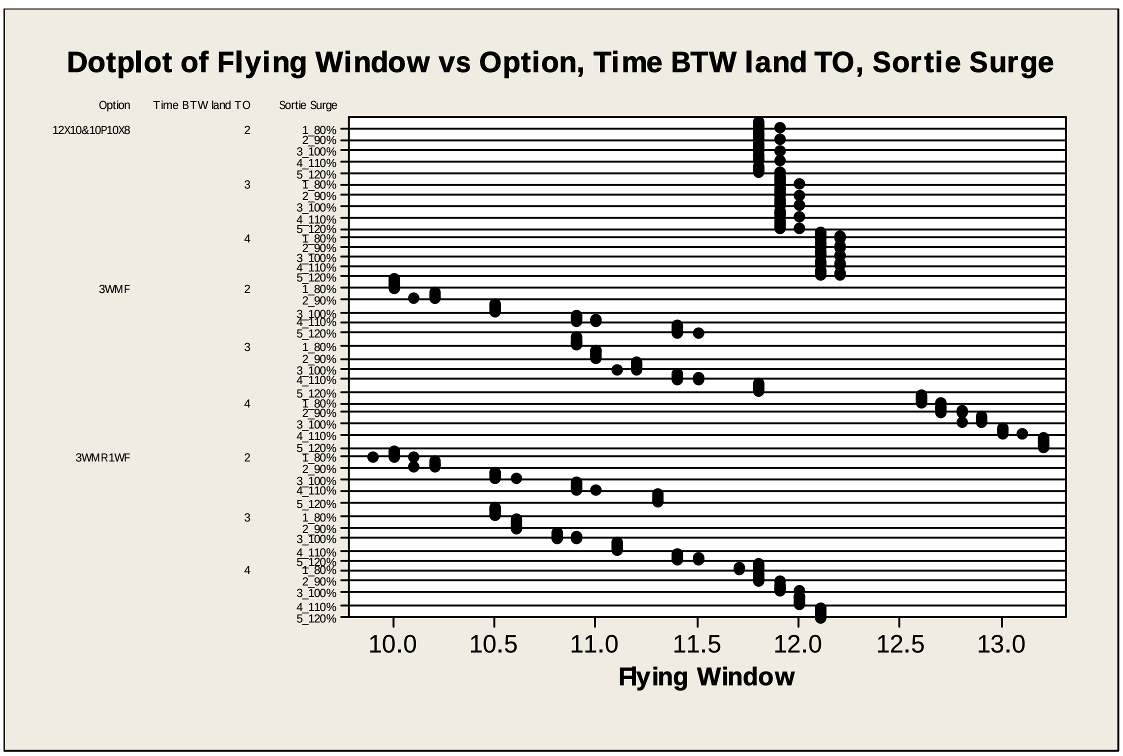


Figure 90. Flying Window Dot-Plot

Analysis of Variance.

Analysis of variance was performed by using the proposed model (figure 62) and the six replications for each treatment (same number of replications across all treatments) in order to obtain a balanced design which would help in Tukey analysis to identify statistically significant differences between the treatment means. Below are the ANOVA results for each output variable.

NMCM Rate.

Summary of fit table, ANOVA table, and Effect Tests table (figures 91, 92, and 93 respectively) indicate that with $\alpha = 0.05$ and R-squared of 0.9759, we get that at least two treatment means differ (p-value in ANOVA table < $\alpha = .05$), and all the effects except the interaction between the 3 factors significantly affect the NMCM Rate (p-values < $\alpha = .05$ in Effect Test table).

Summary of Fit

RSquare	0.975965
RSquare Adj	0.971265
Root Mean Square Error	0.002234
Mean of Response	0.938571
Observations (or Sum Wgts)	270

Figure 91. Summary of Fit for NMCM Rate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	44	0.04561609	0.001037	207.6432
Error	225	0.00112339	0.000005	Prob > F
C. Total	269	0.04673948		<.0001

Figure 92. ANOVA Table for NMCM Rate

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Option	2	2	0.03034570	3038.922	<.0001
Time BTW Land TO	2	2	0.00026470	26.5079	<.0001
Sortie Surge	4	4	0.00945282	473.3187	<.0001
Option*Time BTW Land TO	4	4	0.00041106	20.5827	<.0001
Option*Sortie Surge	8	8	0.00499317	125.0083	<.0001
Time BTW Land TO*Sortie Surge	8	8	0.00008820	2.2081	0.0278
Option*Time BTW Land TO*Sortie Surge	16	16	0.00006044	0.7565	0.7334

Figure 93. Effect Tests for NMCM Rate

The different scheduling philosophy significantly affects the NMCM Rate at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the 1 wave on Fridays approach produce better results than the other scheduling philosophies (Figures 94, 95).

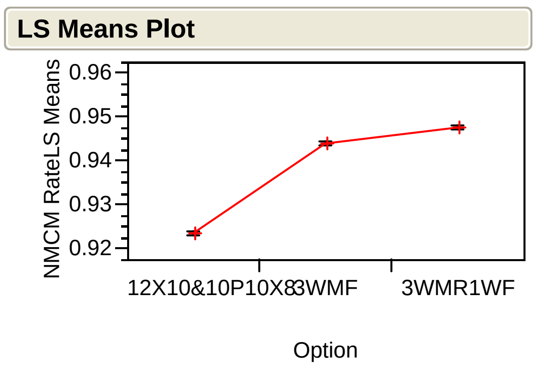


Figure 94. LS Means Plot for Scheduling Philosophy and NMCM Rate

Level		Least Sq Mean
3WMR1WF	A	0.94772958
3WMF	B	0.94427194
12X10&10P10X8	C	0.92371186

Levels not connected by same letter are significantly different

Figure 95. Tukey's Test for Scheduling Philosophy and NMCM Rate

The time between landing and take off significantly affects the NMCM Rate at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant

Difference) test results illustrate that the 2 hours duration between landing and take-off produce better results than the other scheduling philosophies (Figures 96, 97).

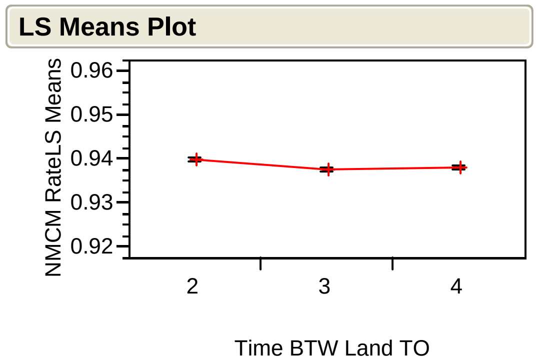


Figure 96. LS Means Plot for Time BTW Landing and Take-off and NMCM Rate

Level			Least Sq Mean
2	A		0.93996387
4		B	0.93800025
3		B	0.93774925

Levels not connected by same letter are significantly different

Figure 97. Tukey's Test for Time BTW Landing and Take-off and NMCM Rate

The Sortie Surge level significantly affects the NMCM Rate at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that with increasing sortie surge the NMCM Rate decreases (Figures 98, 99). This rational result enhances model validation.

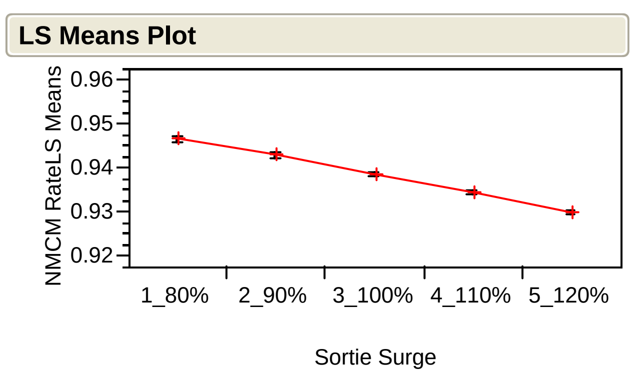


Figure 98. LS Means Plot for Sortie Surge and NMCM Rate

Level		Least Sq Mean
1_80%	A	0.94668823
2_90%	B	0.94301886
3_100%	C	0.93856489
4_110%	D	0.93458564
5_120%	E	0.92999801

Levels not connected by same letter are significantly different

Figure 99. Tukey's Test for Time BTW Landing and Take-off and NMCM Rate

The interaction between the scheduling philosophy and the time between landing and take-off significantly affect the NMCM Rate at $\alpha = .05$. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the 1 wave on Fridays approach performs better at higher duration levels between landing and take-off while the other two scheduling philosophies perform better at lower duration levels.

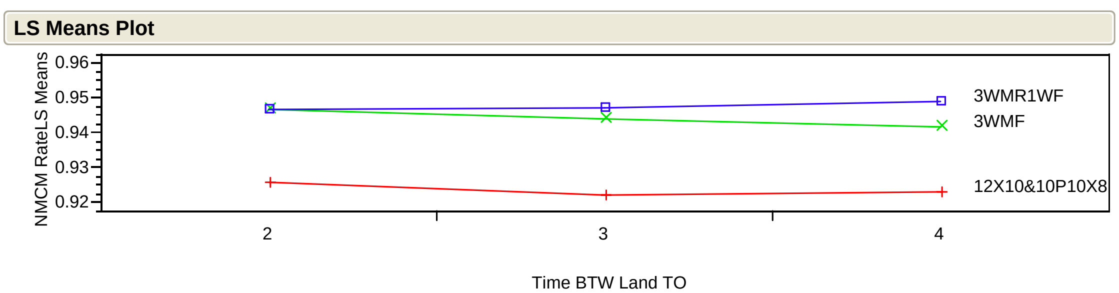


Figure 100. LS Means Plot for Philosophy - Time BTW Land and Take-off Interaction and NMCM Rate

Level							Least Sq Mean
3WMR1WF,4	A						0.94888252
3WMR1WF,3	A	B					0.94727031
3WMR1WF,2		B					0.94703592
3WMF,2		B					0.94693205
3WMF,3			C				0.94392597
3WMF,4				D			0.94195778
12X10&10P10X8,2					E		0.92592364
12X10&10P10X8,4						F	0.92316046
12X10&10P10X8,3						F	0.92205147

Levels not connected by same letter are significantly different

Figure 101. Tukey's Test for Philosophy - Time BTW Land and Take-off Interaction and NMCM Rate

The interaction between the scheduling philosophy and the sortie surge significantly affect the NMCM Rate at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the hot pit refueling approach does not produce decreased NMCM Rates at increased sortie surges. In addition, the one wave on Fridays approach is less influenced by the sortie surges than the 3 waves approach.

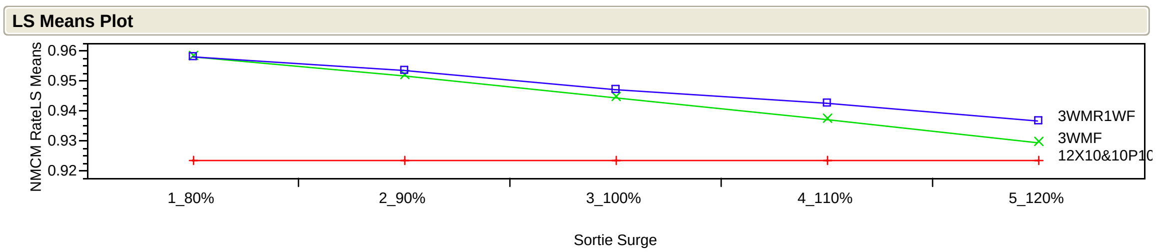


Figure 102. LS Means Plot for Philosophy – Sortie Surge Interaction and NMCM Rate

Level		Least Sq Mean
3WMR1WF,1_80%	A	0.95833063
3WMF,1_80%	A	0.95802219
3WMR1WF,2_90%	B	0.95367607
3WMF,2_90%	B	0.95166866
3WMR1WF,3_100%	C	0.94725093
3WMF,3_100%	C D	0.94473188
3WMR1WF,4_110%	D	0.94271696
3WMF,4_110%	E	0.93732811
3WMR1WF,5_120%	E	0.93667332
3WMF,5_120%	F	0.92960884
12X10&10P10X8,1_80%	G	0.92371186
12X10&10P10X8,2_90%	G	0.92371186
12X10&10P10X8,3_100%	G	0.92371186
12X10&10P10X8,4_110%	G	0.92371186
12X10&10P10X8,5_120%	G	0.92371186

Levels not connected by same letter are significantly different

Figure 103. Tukey's Test for Philosophy – Sortie Surge Interaction and NMCM Rate

The interaction between the sortie surge level and the time between landing and take-off slightly affect the NMCM Rate at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) are presented below:

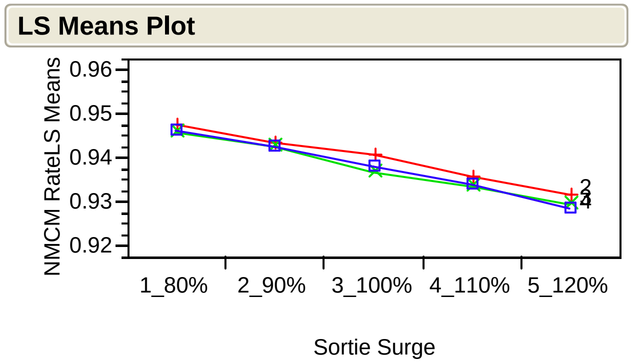


Figure 104. LS Means Plot for Sortie Surge – Time BTW landing Take-off Interaction and NMCM Rate

Level									Least Sq Mean
2,1_80%	A								0.94765260
4,1_80%	A								0.94633765
3,1_80%	A								0.94607444
2,2_90%		B							0.94348864
4,2_90%		B	C						0.94292007
3,2_90%		B	C						0.94264788
2,3_100%			C						0.94091726
4,3_100%				D					0.93817041
3,3_100%				D					0.93660700
2,4_110%				D	E				0.93610457
4,4_110%					E	F			0.93397632
3,4_110%					E	F			0.93367604
2,5_120%						F	G		0.93165629
3,5_120%							G	H	0.92974090
4,5_120%								H	0.92859683

Levels not connected by same letter are significantly different

Figure 105. Tukey's Test for Sortie Surge – Time BTW landing Take-off Interaction and NMCM Rate

AWM.

Summary of fit table, ANOVA table, and Effect Tests table (figures 106, 107, and 108 respectively) indicate that with α = 0.05 and R-squared of 0.9988, we get that at least

two treatment means differ (p-value in ANOVA table < α = .05), and all the effects affect significantly the AWM (p-values < α = .05 in Effect Test table).

Summary of Fit	
RSquare	0.998871
RSquare Adj	0.998651
Root Mean Square Error	0.029034
Mean of Response	11.56108
Observations (or Sum Wgts)	270

Figure. 106 Summary of Fit for AWM

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	44	167.87052	3.81524	4526.026
Error	225	0.18967	0.00084	Prob > F
C. Total	269	168.06018		<.0001

Figure 107. ANOVA Table for AWM

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Option	2	2	30.338433	17995.27	<.0001
Time BTW Land TO	2	2	83.110495	49297.07	<.0001
Sortie Surge	4	4	13.092129	3882.805	<.0001
Option*Time BTW Land TO	4	4	31.126013	9231.212	<.0001
Option*Sortie Surge	8	8	6.623270	982.1497	<.0001
Time BTW Land TO*Sortie Surge	8	8	2.344371	347.6415	<.0001
Option*Time BTW Land TO*Sortie Surge	16	16	1.235806	91.6275	<.0001

Figure 108. Effect Tests for AWM

The different scheduling philosophy significantly affects the AWM at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the 1 wave on Fridays approach produces better results (the lower AWM the better) than the other scheduling philosophies (Figures 109, 110).

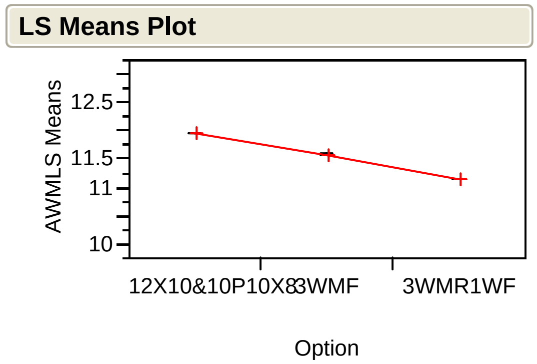


Figure 109. LS Means Plot for Scheduling Philosophy and AWM

Level		Least Sq Mean
12X10&10P10X8	A	11.957930
3WMF	B	11.587210
3WMR1WF	C	11.138090

Levels not connected by same letter are significantly different

Figure 110. Tukey's Test for Scheduling Philosophy and AWM

The time between landing and take off significantly affects the AWM at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the 2 hours duration between landing and take-off produces better results than the other scheduling philosophies (Figures 111, 112).

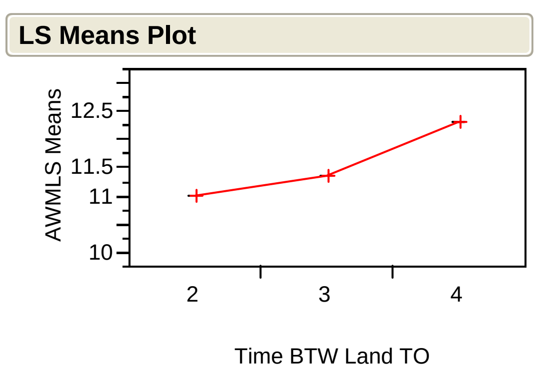


Figure 111. LS Means Plot for Time BTW Landing and Take-off and AWM

Level		Least Sq Mean
4	A	12.317538
3	B	11.363260
2	C	11.002432

Levels not connected by same letter are significantly different

Figure 112. Tukey's Test for Time BTW Landing and Take-off and AWM

The Sortie Surge level significantly affects the AWM at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that with increasing sortie surge the AWM increases (Figures 113, 114). This rational result enhances model validation.

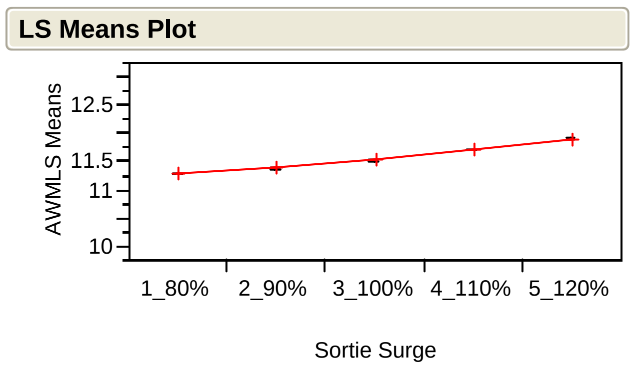


Figure 113. LS Means Plot for Sortie Surge and AWM

Level		Least Sq Mean
5_120%	A	11.903868
4_110%	B	11.703545
3_100%	C	11.521801
2_90%	D	11.380802
1_80%	E	11.295366

Levels not connected by same letter are significantly different

Figure 114. Tukey's Test for Time BTW Landing and Take-off and AWM

The interaction between the scheduling philosophy and the time between landing and take-off significantly affect the AWM at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that all

the scheduling philosophies perform better at lower duration levels between landing and take-off. This result contradicts with the previous finding that the 1 wave on Fridays approach performs better at higher durations in terms of NMCM Rate. In addition, the 3 waves approach is influenced mostly by increased durations rather than the other two approaches.

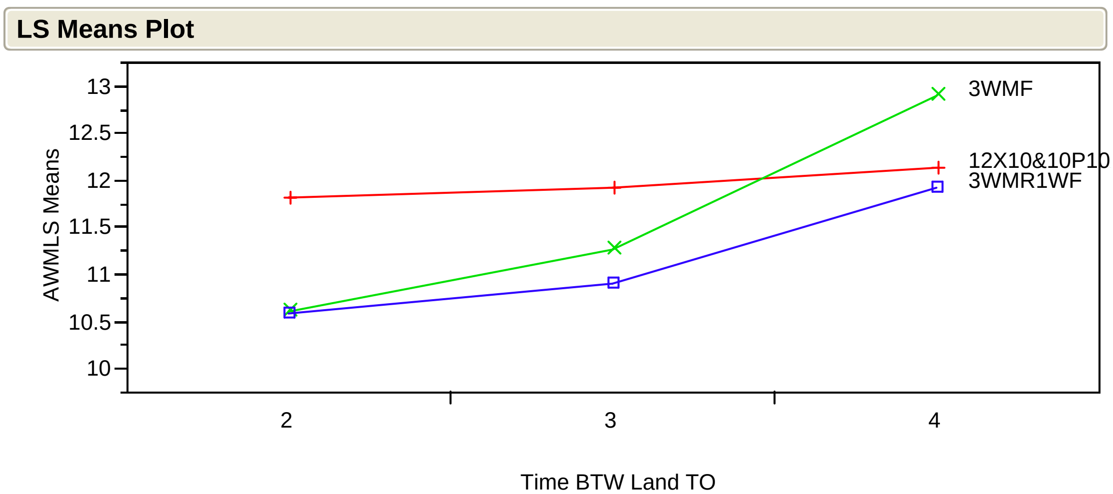


Figure 115. LS Means Plot for Philosophy - Time BTW Land and Take-off Interaction and AWM

Level		Least Sq Mean
3WMF,4	A	12.891077
12X10&10P10X8,4	B	12.136498
3WMR1WF,4	C	11.925041
12X10&10P10X8,3	C	11.915206
12X10&10P10X8,2	D	11.822087
3WMF,3	E	11.272015
3WMR1WF,3	F	10.902558
3WMF,2	G	10.598538
3WMR1WF,2	G	10.586670

Levels not connected by same letter are significantly different

Figure 116. Tukey's Test for Philosophy - Time BTW Land and Take-off Interaction and AWM

The interaction between the scheduling philosophy and the sortie surge significantly affect the AWM at $\alpha = .05$. LS means Plot and LSMeans Differences Tukey

HSD (Honestly Significant Difference) test results illustrate that the hot pit refueling approach does not produce increased AWM at increased sortie surges. In addition, the one wave on Fridays approach is less influenced by the sortie surges than the 3 waves approach, specifically in higher sortie surges.

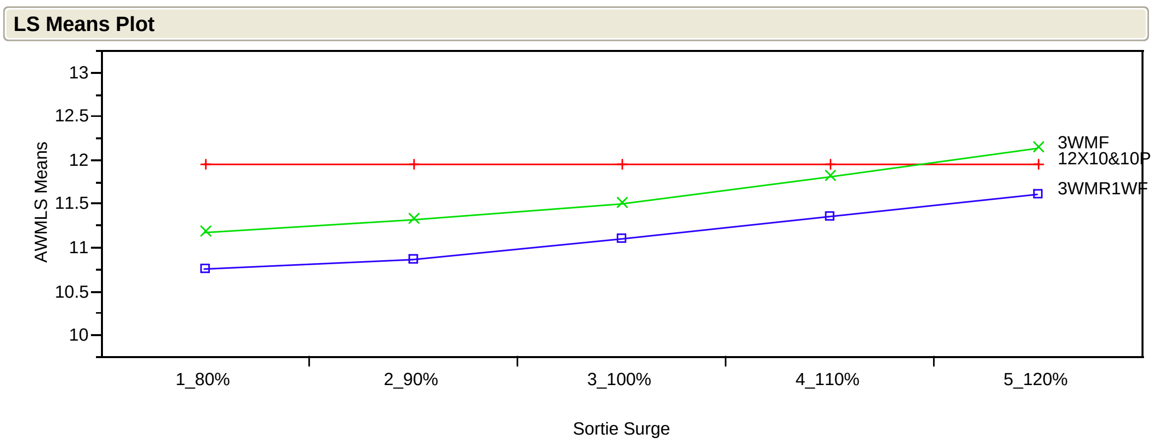


Figure 117. LS Means Plot for Philosophy – Sortie Surge Interaction and AWM

Level												Least Sq Mean
3WMF,5_120%	A											12.139579
12X10&10P10X8,1_80%		B										11.957930
12X10&10P10X8,2_90%		B										11.957930
12X10&10P10X8,3_100%		B										11.957930
12X10&10P10X8,4_110%		B										11.957930
12X10&10P10X8,5_120%		B										11.957930
3WMF,4_110%			C									11.801757
3WMR1WF,5_120%				D								11.614095
3WMF,3_100%					E							11.504946
3WMR1WF,4_110%						F						11.350949
3WMF,2_90%							G					11.311955
3WMF,1_80%								H				11.177813
3WMR1WF,3_100%									I			11.102527
3WMR1WF,2_90%										J		10.872520
3WMR1WF,1_80%											K	10.750356

Levels not connected by same letter are significantly different

Figure 118. Tukey's Test for Philosophy – Sortie Surge Interaction and AWM

The interaction between the sortie surge level and the time between landing and take-off significantly affect the AWM at $\alpha = .05$. LS means Plot and LSMeans

Differences Tukey HSD (Honestly Significant Difference) are presented below (figures 119 and 120). Generally, the lower durations between the landing and take off are more severely impacted by the higher sortie surges in terms of AWM.

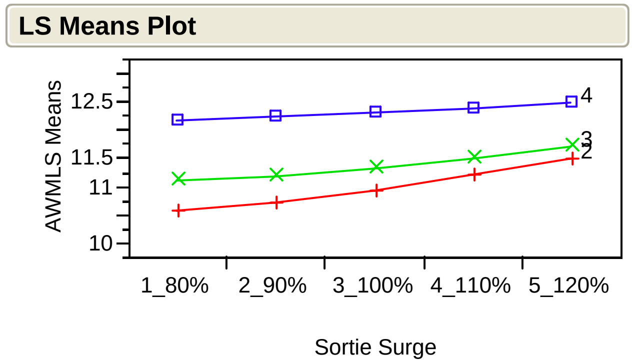


Figure 119. LS Means Plot for Sortie Surge – Time BTW landing Take-off Interaction and AWM

Level		Least Sq Mean
4,5_120%	A	12.477135
4,4_110%	B	12.391885
4,3_100%	C	12.310697
4,2_90%	D	12.232787
4,1_80%	E	12.175188
3,5_120%	F	11.718600
2,5_120%	G	11.515870
3,4_110%	G	11.487634
3,3_100%	H	11.313973
2,4_110%	I	11.231116
3,2_90%	J	11.180326
3,1_80%	K	11.115766
2,3_100%	L	10.940734
2,2_90%	M	10.729292
2,1_80%	N	10.595146

Levels not connected by same letter are significantly different

Figure 120. Tukey's Test for Sortie Surge – Time BTW landing Take-off Interaction and AWM

The interaction between the maintenance philosophy, the sortie surge level and the time between landing and take-off significantly affect the AWM at α = .05. LSMeans Differences Tukey HSD (Honestly Significant Difference) is presented in figure 121. Generally, the lower durations between the landing and take off and the lower sortie

surges perform better regardless of the maintenance scheduling philosophy in terms of AWM. The three waves approach is severely influenced by higher durations between landing and take-off, regardless of the sortie surge.

Level		Least Sq Mean
3WMF,4,5_120%	A	13.180552
3WMF,4,4_110%	B	13.023630
3WMF,4,3_100%	C	12.862701
3WMF,4,2_90%	D	12.747549
3WMF,4,1_80%	E	12.640951
12X10&10P10X8,4,1_80%	F	12.136498
12X10&10P10X8,4,2_90%	F	12.136498
12X10&10P10X8,4,3_100%	F	12.136498
12X10&10P10X8,4,4_110%	F	12.136498
12X10&10P10X8,4,5_120%	F	12.136498
3WMR1WF,4,5_120%	F	12.114355
3WMR1WF,4,4_110%	G	12.015529
3WMR1WF,4,3_100%	H	11.932892
12X10&10P10X8,3,1_80%	H	11.915206
12X10&10P10X8,3,2_90%	H	11.915206
12X10&10P10X8,3,3_100%	H	11.915206
12X10&10P10X8,3,4_110%	H	11.915206
12X10&10P10X8,3,5_120%	H	11.915206
12X10&10P10X8,2,1_80%	I	11.822087
12X10&10P10X8,2,2_90%	I	11.822087
12X10&10P10X8,2,3_100%	I	11.822087
12X10&10P10X8,2,4_110%	I	11.822087
12X10&10P10X8,2,5_120%	I	11.822087
3WMR1WF,4,2_90%	I J	11.814313
3WMF,3,5_120%	I J	11.807351
3WMR1WF,4,1_80%	J	11.748115
3WMF,3,4_110%	K	11.439276
3WMR1WF,3,5_120%	K	11.433242
3WMF,2,5_120%	K	11.430834
3WMR1WF,2,5_120%	L	11.294690
3WMF,3,3_100%	M	11.179644
3WMR1WF,3,4_110%	N	11.108421
3WMF,3,2_90%	O	11.010159
3WMF,2,4_110%	P	10.942364
3WMR1WF,2,4_110%	P	10.928897
3WMF,3,1_80%	P	10.923646
3WMR1WF,3,3_100%	Q	10.847068
3WMR1WF,3,2_90%	R	10.615614
3WMR1WF,2,3_100%	S	10.527623
3WMR1WF,3,1_80%	S	10.508445
3WMF,2,3_100%	S	10.472492
3WMR1WF,2,2_90%	T	10.187633
3WMF,2,2_90%	T	10.178158
3WMR1WF,2,1_80%	U	9.994508
3WMF,2,1_80%	U	9.968843

Levels not connected by same letter are significantly different

Figure 121. Tukey's Test for Maintenance Philosophy - Sortie Surge – Time BTW landing Take-off Interaction and AWM

ATQMA.

Summary of the fit table, the ANOVA table, and the Effect Tests table (figures 122, 123, and 124 respectively) indicate that with α = 0.05 and R-squared of 0.9982, we find that at least two treatment means differ (p-value in ANOVA table < α = .05), and all the effects significantly affect the ATQMA (p-values < α = .05 in Effect Test table).

Summary of Fit	
RSquare	0.998236
RSquare Adj	0.997891
Root Mean Square Error	0.01416
Mean of Response	0.634788
Observations (or Sum Wgts)	270

Figure 122. Summary of Fit for ATQMA

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	44	25.524953	0.580113	2893.073
Error	225	0.045116	0.000201	Prob > F
C. Total	269	25.570070		<.0001

Figure 123. ANOVA Table for ATQMA

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Option	2	2	16.719178	41690.02	<.0001
Time BTW Land TO	2	2	1.745526	4352.546	<.0001
Sortie Surge	4	4	4.104250	5117.066	<.0001
Option*Time BTW Land TO	4	4	0.394738	492.1480	<.0001
Option*Sortie Surge	8	8	2.352457	1466.489	<.0001
Time BTW Land TO*Sortie Surge	8	8	0.118722	74.0095	<.0001
Option*Time BTW Land TO*Sortie Surge	16	16	0.090083	28.0784	<.0001

Figure 124. Effect Tests for ATQMA

The different scheduling philosophy significantly affects the ATQMA at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the 1 wave on Fridays approach produces better results (the lower ATQMA the better) than the other scheduling philosophies (Figures 125, 126).

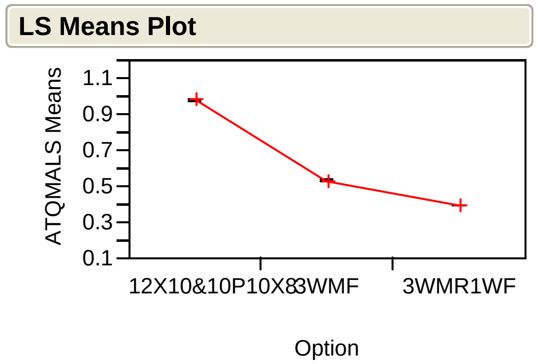


Figure 125. LS Means Plot for Scheduling Philosophy and ATQMA

Level				Least Sq Mean
12X10&10P10X8	A			0.97784501
3WMF		B		0.53121652
3WMR1WF			C	0.39530214

Levels not connected by same letter are significantly different

Figure 126. Tukey's Test for Scheduling Philosophy and ATQMA

The time between landing and take off significantly affects the ATQMA at $\alpha = .05$. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the 2 hours duration between landing and take-off produces better results than the other scheduling philosophies (Figures 127, 128).

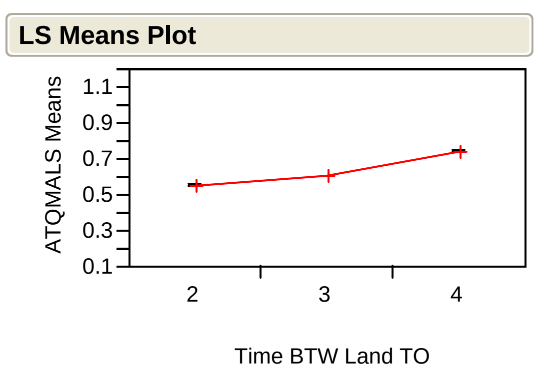


Figure 127. LS Means Plot for Time BTW Landing and Take-off and ATQMA

Level				Least Sq Mean
4	A			0.74441051
3		B		0.60613999
2			C	0.55381316

Levels not connected by same letter are significantly different

Figure 128. Tukey's Test for Time BTW Landing and Take-off and ATQMA

The Sortie Surge level significantly affects the ATQMA at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that with increasing sortie surge the ATQMA increases (Figures 129, 130). This rational result enhances model validation.

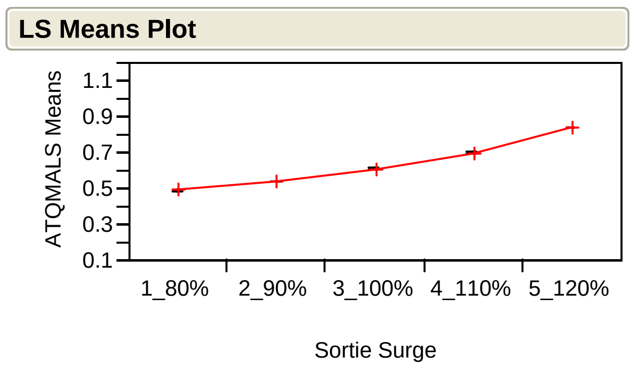


Figure 129. LS Means Plot for Sortie Surge and ATQMA

Level						Least Sq Mean
5_120%	A					0.83837299
4_110%		B				0.69678620
3_100%			C			0.61030370
2_90%				D		0.53715185
1_80%					E	0.49132472

Levels not connected by same letter are significantly different

Figure 130. Tukey's Test for Time BTW Landing and Take-off and ATQMA

The interaction between the scheduling philosophy and the time between landing and take-off significantly affect the ATQMA at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that all the scheduling philosophies perform better at lower duration levels between landing and

take-off. This result contradicts with the previous finding that the 1 wave on Fridays approach performs better at higher durations in terms of NMCM Rate. In addition, the 1 wave on Fridays approach is less influenced by increased durations rather than the other two approaches.

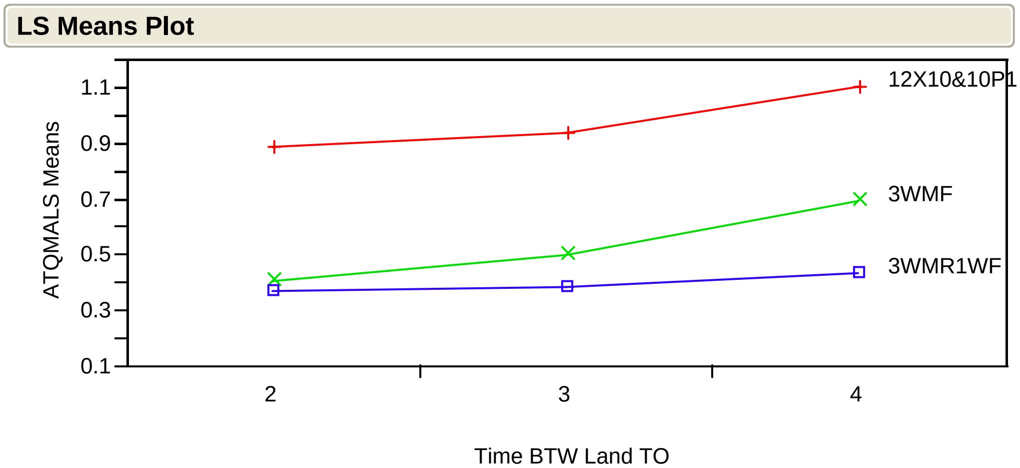


Figure 131. LS Means Plot for Philosophy - Time BTW Land and Take-off Interaction and ATQMA

Level		Least Sq Mean
12X10&10P10X8,4	A	1.1028802
12X10&10P10X8,3	B	0.9406978
12X10&10P10X8,2	C	0.8899570
3WMF,4	D	0.6937190
3WMF,3	E	0.4965845
3WMR1WF,4	F	0.4366323
3WMF,2	G	0.4033460
3WMR1WF,3	H	0.3811376
3WMR1WF,2	I	0.3681365

Levels not connected by same letter are significantly different

Figure 132. Tukey's Test for Philosophy - Time BTW Land and Take-off Interaction and ATQMA

The interaction between the scheduling philosophy and the sortie surge significantly affect the ATQMA at $\alpha = .05$. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the hot pit

refueling approach does not produce increased ATQMA at increased sortie surges. In addition, the one wave on Fridays approach is less influenced by the sortie surges than the 3 waves approach, specifically in higher sortie surges.

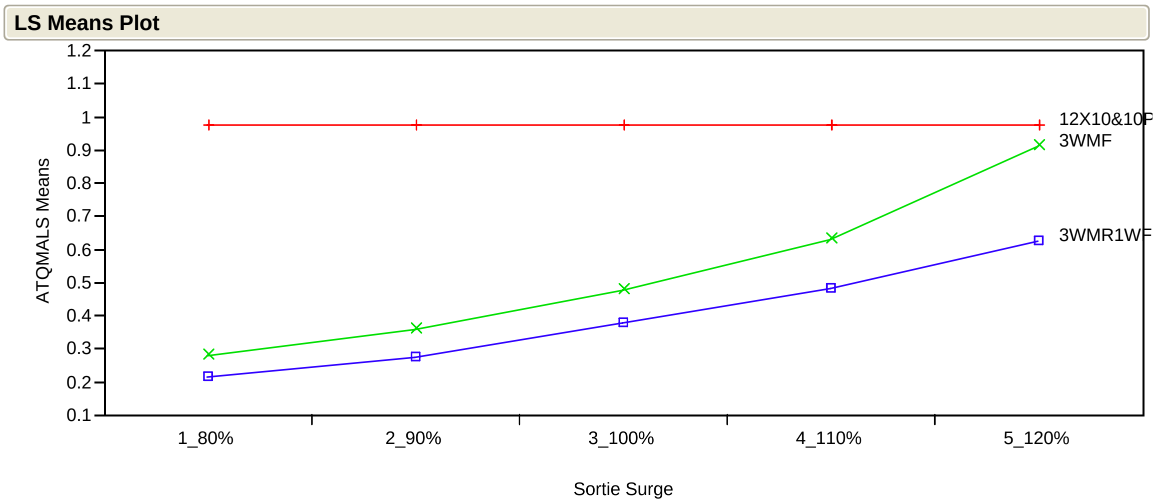


Figure 133. LS Means Plot for Philosophy – Sortie Surge Interaction and ATQMA

Level									Least Sq Mean
12X10&10P10X8,1_80%	A								0.97784501
12X10&10P10X8,2_90%	A								0.97784501
12X10&10P10X8,3_100%	A								0.97784501
12X10&10P10X8,4_110%	A								0.97784501
12X10&10P10X8,5_120%	A								0.97784501
3WMF,5_120%		B							0.91252652
3WMF,4_110%			C						0.63209562
3WMR1WF,5_120%			C						0.62474743
3WMR1WF,4_110%				D					0.48041796
3WMF,3_100%				D					0.47496940
3WMR1WF,3_100%					E				0.37809670
3WMF,2_90%						F			0.35839652
3WMF,1_80%							G		0.27809454
3WMR1WF,2_90%							G		0.27521401
3WMR1WF,1_80%								H	0.21803460

Levels not connected by same letter are significantly different

Figure 134. Tukey's Test for Philosophy – Sortie Surge Interaction and ATQMA

The interaction between the sortie surge level and the time between landing and take-off significantly affect the ATQMA at α = .05. LS means Plot and LSMeans

Differences Tukey HSD (Honestly Significant Difference) are presented below (figures 135 and 136). Generally, the higher sortie surge is the lower duration between landing and take-off in order to get the same ATQMA.

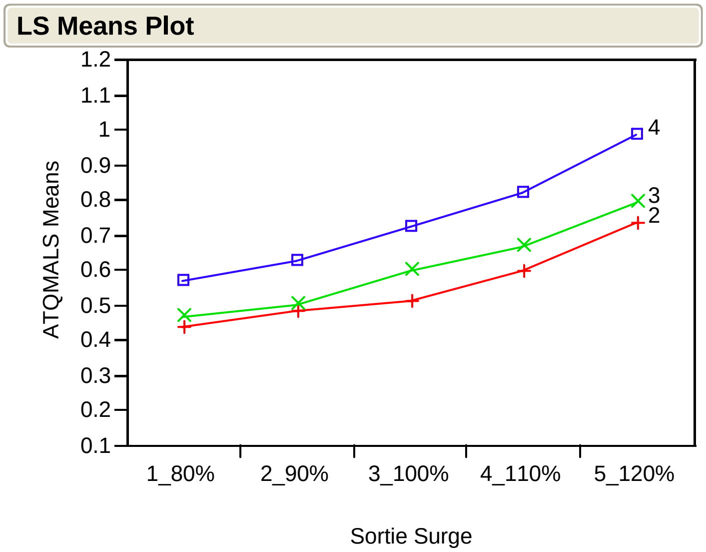


Figure 135. LS Means Plot for Sortie Surge – Time BTW landing Take-off Interaction and ATQMA

Level		Least Sq Mean
4,5_120%	A	0.98735869
4,4_110%	B	0.82069638
3,5_120%	C	0.79067946
2,5_120%	D	0.73708082
4,3_100%	D	0.72205406
3,4_110%	E	0.66987336
4,2_90%	F	0.62442304
2,4_110%	G	0.59978885
3,3_100%	G	0.59802807
4,1_80%	H	0.56752040
2,3_100%	I	0.51082897
3,2_90%	I	0.50303427
2,2_90%	J	0.48399823
3,1_80%	J	0.46908481
2,1_80%	K	0.43736894

Levels not connected by same letter are significantly different

Figure 136. Tukey's Test for Sortie Surge – Time BTW landing Take-off Interaction and ATQMA

The interaction between the maintenance philosophy, the sortie surge level and the time between landing and take-off significantly affect the ATQMA at α = .05. LSMeans Differences Tukey HSD (Honestly Significant Difference) is presented in figure 137.

Level		Least Sq Mean
3WMF,4,5_120%	A	1.1670403
12X10&10P10X8,4,2_90%	B	1.1028802
12X10&10P10X8,4,3_100%	B	1.1028802
12X10&10P10X8,4,4_110%	B	1.1028802
12X10&10P10X8,4,5_120%	B	1.1028802
12X10&10P10X8,4,1_80%	B	1.1028802
12X10&10P10X8,3,1_80%	C	0.9406978
12X10&10P10X8,3,4_110%	C	0.9406978
12X10&10P10X8,3,5_120%	C	0.9406978
12X10&10P10X8,3,3_100%	C	0.9406978
12X10&10P10X8,3,2_90%	C	0.9406978
12X10&10P10X8,2,1_80%	D	0.8899570
12X10&10P10X8,2,4_110%	D	0.8899570
12X10&10P10X8,2,3_100%	D	0.8899570
12X10&10P10X8,2,2_90%	D	0.8899570
12X10&10P10X8,2,5_120%	D	0.8899570
3WMF,3,5_120%	E	0.8369201
3WMF,4,4_110%	E	0.8148548
3WMF,2,5_120%	F	0.7336191
3WMR1WF,4,5_120%	G	0.6921555
3WMF,4,3_100%	H	0.6353376
3WMF,3,4_110%	H I	0.6099952
3WMR1WF,3,5_120%	I	0.5944204
3WMR1WF,2,5_120%	I	0.5876663
3WMR1WF,4,4_110%	J	0.5443541
3WMF,4,2_90%	K	0.4745991
3WMF,2,4_110%	K	0.4714369
3WMF,3,3_100%	K L	0.4663282
3WMR1WF,3,4_110%	K L M	0.4589271
3WMR1WF,2,4_110%	L M	0.4379727
3WMR1WF,4,3_100%	M	0.4279444
3WMR1WF,3,3_100%	N	0.3870582
3WMF,4,1_80%	N	0.3767633
3WMF,2,3_100%	O	0.3232425
3WMR1WF,2,3_100%	O	0.3192875
3WMF,3,2_90%	O P	0.3159525
3WMR1WF,4,2_90%	O P Q	0.2957898
3WMF,2,2_90%	P Q R	0.2846380
3WMR1WF,2,2_90%	Q R	0.2773997
3WMF,3,1_80%	R S	0.2537266
3WMR1WF,3,2_90%	R S	0.2524525
3WMR1WF,4,1_80%	S T	0.2229177
3WMR1WF,2,1_80%	T	0.2183561
3WMR1WF,3,1_80%	T	0.2128300
3WMF,2,1_80%	T	0.2037937

Levels not connected by same letter are significantly different

Figure 137. Tukey's Test for Maintenance Philosophy - Sortie Surge – Time BTW landing Take-off Interaction and ATQMA

Generally, the lower durations between the landing and take off and the lower sortie surges perform better regardless of the maintenance scheduling philosophy in terms of ATQMA. The three waves approach is severely influenced by higher durations between landing and take-off and higher sortie surge.

Flying Window.

Summary of the fit table, the ANOVA table, and the Effect Tests table (figures 138, 139, and 140 respectively) indicate that with $\alpha = 0.05$ and R-squared of 0.9811, we get that at least two treatment means differ (p-value in ANOVA table < $\alpha = .05$), and all the effects affect significantly the Flying Window (p-values < $\alpha = .05$ in Effect Test table).

Summary of Fit	
RSquare	0.981107
RSquare Adj	0.977413
Root Mean Square Error	0.910353
Mean of Response	21.88347
Observations (or Sum Wgts)	270

Figure 138. Summary of Fit for Flying Window

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	44	9683.2735	220.074	265.5523
Error	225	186.4670	0.829	Prob > F
C. Total	269	9869.7405		<.0001

Figure 139. ANOVA Table for Flying Window

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Option	2	2	8242.3935	4972.833	<.0001
Time BTW Land TO	2	2	361.6084	218.1670	<.0001
Sortie Surge	4	4	465.6961	140.4828	<.0001
Option*Time BTW Land TO	4	4	214.2545	64.6324	<.0001
Option*Sortie Surge	8	8	291.8353	44.0178	<.0001
Time BTW Land TO*Sortie Surge	8	8	43.4411	6.5523	<.0001
Option*Time BTW Land TO*Sortie Surge	16	16	64.0446	4.8300	<.0001

Figure 140. Effect Tests for Flying Window

The different scheduling philosophy significantly affects the Flying Window at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the 1 wave on Fridays approach produces better results (the lower Flying Window the better) than the other scheduling philosophies (Figures 141, 142).

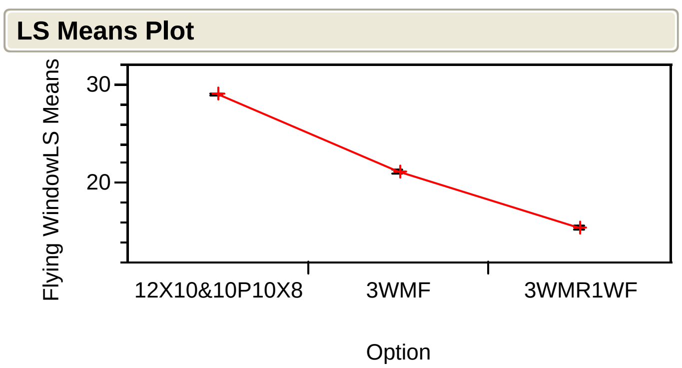


Figure 141. LS Means Plot for Scheduling Philosophy and Flying Window

Level				Least Sq Mean
12X10&10P10X8	A			28.980365
3WMF		B		21.166374
3WMR1WF			C	15.503658

Levels not connected by same letter are significantly different

Figure 142. Tukey's Test for Scheduling Philosophy and Flying Window

The time between landing and take off significantly affects the Flying Window at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant

Difference) test results illustrate that the 2 hours duration between landing and take-off produces better results than the other scheduling philosophies (Figures 143, 144). The impact is not so severe at higher durations between landing and take-off.

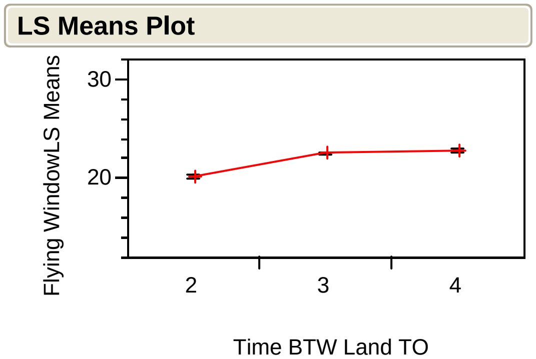


Figure 143. LS Means Plot for Time BTW Landing and Take-off and Flying Window

Level				Least Sq Mean
4	A			22.875806
3		B		22.514407
2			C	20.260184

Levels not connected by same letter are significantly different

Figure 144. Tukey’s Test for Time BTW Landing and Take-off and Flying Window

The Sortie Surge level significantly affects the Flying Window at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that with increasing sortie surge the Flying Window increases (Figures 145, 146). This rational result enhances model validation.

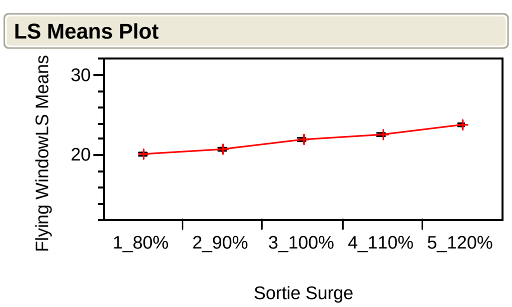


Figure 145. LS Means Plot for Sortie Surge and Flying Window

Level						Least Sq Mean
5_120%	A					23.861019
4_110%		B				22.560123
3_100%			C			22.057879
2_90%				D		20.804147
1_80%					E	20.134160

Levels not connected by same letter are significantly different

Figure 146. Tukey's Test for Time BTW Landing and Take-off and Flying Window

The interaction between the scheduling philosophy and the time between landing and take-off significantly affect the Flying Window at α = .05. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that all the scheduling philosophies perform better at lower duration levels between landing and take-off. The 1 wave on Fridays approach is less influenced by increased durations between landing and take-off and the hot pit refueling approach does not perform well at mid-levels of duration.

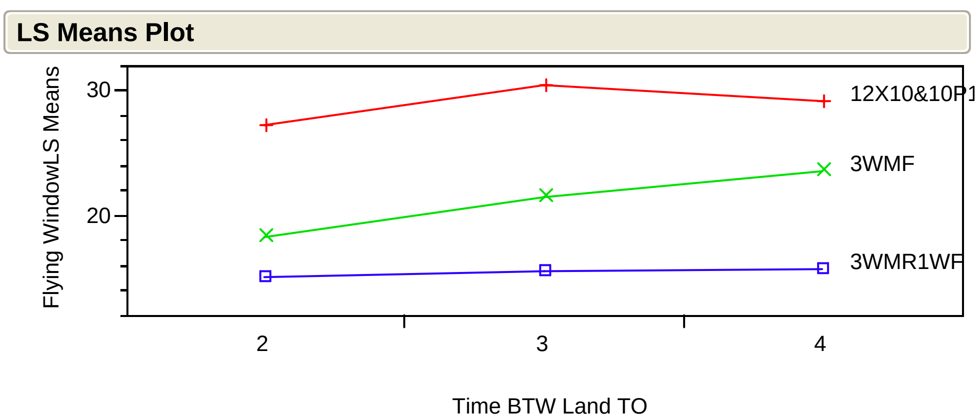


Figure 147. LS Means Plot for Philosophy - Time BTW Land and Take-off Interaction and Flying Window

Level		Least Sq Mean
12X10&10P10X8,3	A	30.461362
12X10&10P10X8,4	B	29.163340
12X10&10P10X8,2	C	27.316393
3WMF,4	D	23.638152
3WMF,3	E	21.468855
3WMF,2	F	18.392116
3WMR1WF,4	G	15.825927
3WMR1WF,3	G H	15.613003
3WMR1WF,2	H	15.072042

Levels not connected by same letter are significantly different

Figure 148. Tukey's Test for Philosophy - Time BTW Land and Take-off Interaction and Flying Window

The interaction between the scheduling philosophy and the sortie surge significantly affect the Flying Window at $\alpha = .05$. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) test results illustrate that the hot pit refueling approach does not produce increased Flying Window at increased sortie surges. In addition, the one wave on Fridays approach is less influenced by the sortie surges than the 3 waves approach specifically in higher sortie surges.

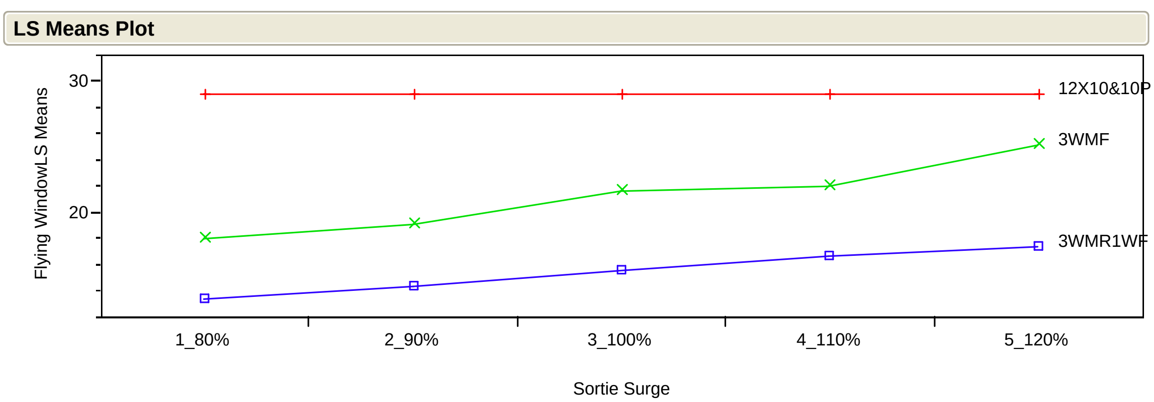


Figure 149. LS Means Plot for Philosophy – Sortie Surge Interaction and Flying Window

Level		Least Sq Mean
12X10&10P10X8,1_80%	A	28.980365
12X10&10P10X8,2_90%	A	28.980365
12X10&10P10X8,3_100%	A	28.980365
12X10&10P10X8,4_110%	A	28.980365
12X10&10P10X8,5_120%	A	28.980365
3WMF,5_120%	B	25.160880
3WMF,4_110%	C	22.012446
3WMF,3_100%	C	21.588691
3WMF,2_90%	D	19.096066
3WMF,1_80%	E	17.973789
3WMR1WF,5_120%	E F	17.441812
3WMR1WF,4_110%	F	16.687560
3WMR1WF,3_100%	G	15.604580
3WMR1WF,2_90%	H	14.336010
3WMR1WF,1_80%	H	13.448326

Levels not connected by same letter are significantly different

Figure 150. Tukey's Test for Philosophy – Sortie Surge Interaction and Flying Window

The interaction between the sortie surge level and the time between landing and take-off significantly affect the Flying Window at $\alpha = .05$. LS means Plot and LSMeans Differences Tukey HSD (Honestly Significant Difference) are presented below (figures 151 and 152). The 2-hour duration between the landing and take-off performs better than the other approaches regardless of the sortie surge. In addition, the 4-hour duration between the landing and take-off seems to perform better than the 3-hour duration at higher sortie surges.

The interaction between the maintenance philosophy, the sortie surge level and the time between landing and take-off significantly affect the Flying Window at $\alpha = .05$. LSMeans Differences Tukey HSD (Honestly Significant Difference) is presented in figure 153. Generally, the lower durations between the landing and take off and the lower sortie surges perform better regardless of the maintenance scheduling philosophy in terms

of Flying Window. The three waves approach is severely influenced by higher durations between landing and take-off and higher sortie surge.

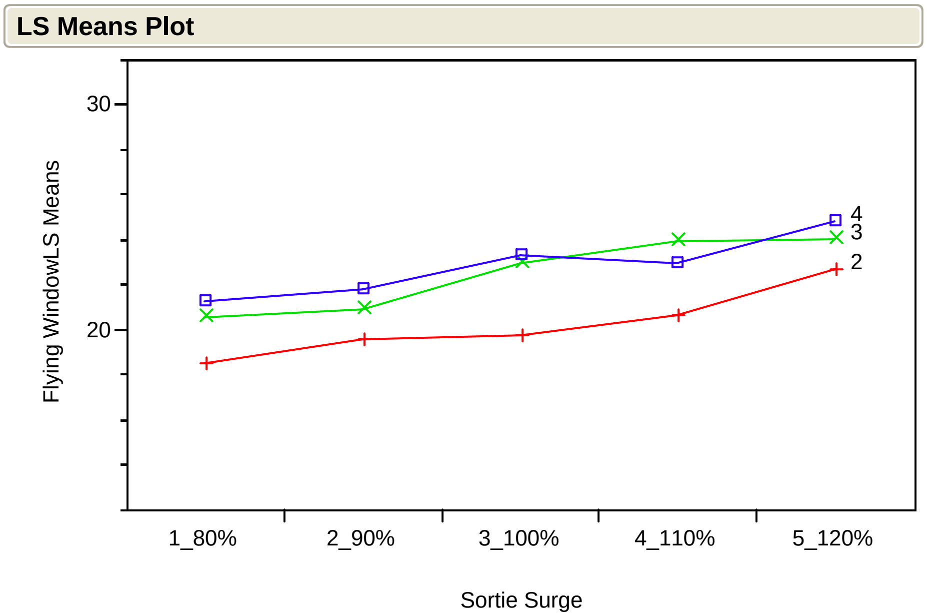


Figure 151. LS Means Plot for Sortie Surge – Time BTW landing Take-off Interaction and Flying Window

Level		Least Sq Mean
4,5_120%	A	24.872503
3,5_120%	A B	24.022491
3,4_110%	A B	23.980700
4,3_100%	B C	23.352404
4,4_110%	B C	23.009393
3,3_100%	B C	22.999883
2,5_120%	C D	22.688063
4,2_90%	D E	21.839848
4,1_80%	E F	21.304884
3,2_90%	E F	20.976370
2,4_110%	F G	20.690278
3,1_80%	F G H	20.592590
2,3_100%	G H	19.821349
2,2_90%	H	19.596223
2,1_80%	I	18.505005

Levels not connected by same letter are significantly different

Figure 152. Tukey's Test for Sortie Surge – Time BTW landing Take-off Interaction and Flying Window

Level		Least Sq Mean
12X10&10P10X8,3,5_120%	A	30.461362
12X10&10P10X8,3,1_80%	A	30.461362
12X10&10P10X8,3,2_90%	A	30.461362
12X10&10P10X8,3,3_100%	A	30.461362
12X10&10P10X8,3,4_110%	A	30.461362
12X10&10P10X8,4,5_120%	A B	29.163340
12X10&10P10X8,4,3_100%	A B	29.163340
12X10&10P10X8,4,1_80%	A B	29.163340
12X10&10P10X8,4,2_90%	A B	29.163340
12X10&10P10X8,4,4_110%	A B	29.163340
3WMF,4,5_120%	B	27.708676
12X10&10P10X8,2,4_110%	B	27.316393
12X10&10P10X8,2,1_80%	B	27.316393
12X10&10P10X8,2,2_90%	B	27.316393
12X10&10P10X8,2,5_120%	B	27.316393
12X10&10P10X8,2,3_100%	B	27.316393
3WMF,3,5_120%	C	24.383741
3WMF,3,4_110%	C	24.356380
3WMF,4,3_100%	C D	23.973417
3WMF,2,5_120%	C D	23.390223
3WMF,4,4_110%	C D E	23.110946
3WMF,4,2_90%	D E	22.207647
3WMF,3,3_100%	D E	22.049041
3WMF,4,1_80%	E	21.190075
3WMF,2,3_100%	F	18.743614
3WMF,2,4_110%	F G	18.570011
3WMF,3,2_90%	F G	18.466240
3WMF,3,1_80%	F G H	18.088873
3WMR1WF,4,5_120%	F G H	17.745494
3WMR1WF,2,5_120%	F G H	17.357573
3WMR1WF,3,5_120%	F G H	17.222369
3WMR1WF,3,4_110%	F G H	17.124358
3WMR1WF,4,3_100%	F G H I	16.920456
3WMR1WF,4,4_110%	F G H I	16.753892
3WMF,2,2_90%	G H I J	16.614312
3WMR1WF,3,3_100%	G H I J	16.489246
3WMR1WF,2,4_110%	H I J K	16.184430
3WMR1WF,2,2_90%	I J K L	14.857965
3WMF,2,1_80%	J K L	14.642419
3WMR1WF,4,2_90%	K L	14.148557
3WMR1WF,3,2_90%	L	14.001507
3WMR1WF,4,1_80%	L	13.561237
3WMR1WF,2,1_80%	L	13.556204
3WMR1WF,2,3_100%	L	13.404040
3WMR1WF,3,1_80%	L	13.227536

Levels not connected by same letter are significantly different

Figure 153. Tukey's Test for Maintenance Philosophy - Sortie Surge – Time BTW landing Take-off Interaction and Flying Window

Summary

This chapter exhibits the results of the Delphi Study, the content analysis, and the simulation model conducted for this research. The most significant maintenance scheduling philosophies were identified to be the “3 waves Monday through Friday”, the “3 waves Monday through Thursday and 1 wave on Friday”, and the “12 turn 10 jets for three weeks and 10 hot-pit 10 turn 8 jets for 1 week”. The most significant metric in terms of the long term health of the fleet was identified to be the Not Mission Capable for Maintenance Rate (NMCM Rate). The most significant metrics in terms of the maintenance effectiveness to meet unit sortie production goals were identified to be the discrepancies awaiting maintenance (AWM), the average time in maintenance activity queues (ATQMA) and the flying window. The uniformity of the schedule (balanced – unbalanced approach) didn’t seem to affect the output variables. On the other hand, any reduction on current level of maintenance personnel caused an inability to meet the required sortie schedule. The significant factors that affect the long term health of the fleet and the maintenance effectiveness were identified to be the maintenance scheduling philosophy, the sortie rate, the time between landing and take-off, and the interaction of those as well. The “3 waves Monday through Thursday and 1 wave on Friday” maintenance scheduling philosophy seems to outperform the other two philosophies regardless of the sortie surge level or the time between landing and take off. This philosophy is also less sensitive than the “3 waves Monday through Friday” scheduling philosophy in sortie level and time between landing and take-off changes.

The following chapter proposes some conclusions about the findings of this research and some recommendations for further study.

V. Conclusion

Introduction

The previous four chapters introduced the research that was undertaken, reviewed the literature, defined the methodology, established the simulation model and analyzed the output of the results. The research that has been described by these chapters identified the commonly used maintenance scheduling philosophies and the metrics that capture the long term health of the fleet and the maintenance effectiveness to meet unit sortie production goal. It also identified the factors that affect the long term health of the fleet and maintenance effectiveness and proposed which of the factors seem better than the others and under what situations. This chapter will conclude this research and discuss future research areas.

Recommendations to Eielson AFB

This research identified that the most significant maintenance scheduling philosophies are the "3 waves Monday through Friday – 3WMF", the "3 waves Monday through Thursday and 1 wave on Friday – 3WMR1WF", and the "12 turn 10 jets for three weeks and 10 hot-pit 10 turn 8 jets for 1 week – 12X10&10P10X8". The most significant metric in terms of the long term health of the fleet was identified to be the Not Mission Capable for Maintenance Rate (NMCM Rate). The most significant metrics in terms of the maintenance effectiveness to meet unit sortie production goals were identified to be the discrepancies awaiting maintenance (AWM), the average time in maintenance activity queues (ATQMA) and the flying window. The uniformity of the schedule (balanced – unbalanced approach) didn't seem to affect the output variables. On

the other hand, any reduction on current level of maintenance personnel caused an inability to meet the required sortie schedule. The significant factors that affect the long term health of the fleet and the maintenance effectiveness were identified to be the maintenance scheduling philosophy, the sortie rate, the time between landing and take-off, and the interaction of those as well. The “3 waves Monday through Thursday and 1 wave on Friday” maintenance scheduling philosophy seems to outperform the other two philosophies regardless the sortie surge level or the time between landing and take off. This philosophy is also less sensitive than the “3 waves Monday through Friday” scheduling philosophy in sortie level and time between landing and take-off changes.

Tables 4 and 5 illustrate the proposed maintenance scheduling philosophy for various sortie levels and time between landing and take-off levels in terms of long term heath of the fleet and maintenance effectiveness respectively. Philosophies with green color are recommended, with orange color are close to the recommended solutions and their application could be under consideration by the user, and with red color are not recommended. These tables should serve as the final recommendation to Eielson AFB of when to use each particular scheduling philosophy based on the sortie levels and the times between landing and take-off.

Recommendations for Further Research

A variety of opportunities exist to make significant improvements in this research. Below are some potential enhancements that future researchers might consider:

1. Enhance external validity (generalization) of the research by using the same model for another F-16 unit and with minor changes for a unit with a different type of aircraft.
2. Perform the same Delphi study with a different sample and not limited to AFIT personnel to compare the Delphi responses.
3. Perform a more detailed analysis and experiment of the manning level and determine which Primary Working Center (PWC) is the bottleneck in the sortie generation process.
4. Relax the assumption of the FIFO (first In First Out) approach in assigning aircraft to missions by modeling different approaches such as assigning aircraft to missions based on the type of the mission, the configuration of the aircraft, the accomplished TCTO's, the aircraft's reliability, or its remaining flying hours until scheduled inspection.
5. Model a self-learning system that will continuously try to achieve specific targets by changing the daily schedule based on currently achieved metrics.
6. Perform sensitivity analysis on the time that each shift shows up and on the manning level of each PWC and each shift. The GUI (Graphical User Interface) has already been design to foster this analysis.
7. Perform a sensitivity analysis on the dispatching rule of each maintenance process. Various dispatching rules could be the FIFO approach, the lowest duration, the highest duration, or the number (lowest or highest) of needed personnel to perform the task, etc.

8. Perform an analysis on the Repeat / Recur rate metric to identify which part of it is due to improper maintenance and what part is caused by the "unhealthiness" of the fleet.

Table 4. Proposed Scheduling Philosophy for Long Term Health of the Fleet

		Sortie Levels (percentage of the current sortie levels)					
		80%	90%	100%	110%	120%	>120% (untested)
Time BTW Landing & Take-Off	2	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8
	3	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8
	4	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8
	>4	Not recommended					

Table 5. Proposed Scheduling Philosophy for Maintenance Effectiveness

		Sortie Levels (percentage of the current sortie levels)					
		80%	90%	100%	110%	120%	>120% (untested)
Time BTW Landing & Take-Off	2	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8
	3	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8
	4	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8	3WMR1WF 3WMF 12X10&10P10X8
	>4	Not recommended					

VI. Appendix “A”. Key Metrics (AFLMA, 2002)

Table 6. Key Metrics

METRIC	DESCRIPTION	THINGS TO LOOK FOR
MC Rate	The percentage of possessed hours for aircraft that can fly at least one assigned mission. Desired Trend: ↑	Workers putting off repairs to other shifts, inexperienced workers, lack of parts from supply, poor in-shop scheduling, high cannibalization rates, training deficiencies – formal or OJT. High commitment rates may also contribute to a lower MC Rate.
NMCM Rate	The percentage of possessed hours for aircraft that cannot fly any assigned mission due to maintenance. Desired Trend: ↓	Workers putting off repairs to other shifts, inexperienced workers, lack of manpower, lack of tools, lack of support equipment, training issues, environmental factors. Look at the impact of scheduled versus unscheduled maintenance.
NMCS Rate	The percentage of possessed hours for aircraft that cannot fly any assigned mission due to lack of parts. Desired Trend: ↓	Backshops slow turning out parts, lack of in-shop technical repair data, lack of shop replaceable units and bits and pieces, stock level problems, transportation issues affecting delivery of parts.
FSE Rate	The percentage of sorties scheduled minus deviations. Desired Trend: ↑	Last minute aircraft being added to the schedule, frequent configuration changes, frequent changes to the flying schedule, lack of discipline on who is authorized to change the flying schedule.
CANN Rate	The number of cannibalizations that occur per sortie (per 100 sorties for Mobility Air Force, MAF) or for supply kit deployment. Desired Trend: ↓	Reliability of parts, problems at shop or depot repair facility, lack of discipline or supervision, poor sense of urgency, supply problems, kit fill rates, parts that never had to be CANNed before (old airplanes breaking for new reasons, insufficient stockage levels on base, having to manage parts for deployments). Analyze the cause codes of CANNS. Are the parts being CANNed authorized to be on hand?

Table 6. Continued

METRIC	DESCRIPTION	THINGS TO LOOK FOR
Abort Rate	The number of air aborts plus ground aborts occurring per total number of sorties. Desired Trend: ↓	Quality of maintenance decreasing, especially if aborts caused by R/R write-ups or aircrews not proficient on newer systems (leading to erroneous write-ups), reliability problems or issues.
Break Rate	The number of aircraft landing with a grounding write-up per total number of sorties. Desired Trend: ↓	Reliability of parts, training deficiency, poor technical data, test equipment, or insufficient tools.
Fix Rate	The number of grounding write-ups repaired per the total number of grounding write-ups that occurred. Desired Trend: ↑	Training, lack of experienced technicians, poor technical data, lack of tools, or lack of test equipment.
R/R Rate	The number of R/R write-ups per the total number of write-ups. Desired Trend: ↓	Component reliability, maintenance practices, or experience of maintenance technicians.
Maintenance Scheduling Effectiveness Rate	The number of maintenance actions started as scheduled per total number of maintenance actions scheduled. Desired Trend: ↑	If either the unit or individual tail number rates increase, look for: 7. Shortages in equipment or personnel, 8. Problems with a particular type of maintenance action being accomplished later than scheduled, and 9. Resources being over committed
Deferred Discrepancies	Depicts how well your unit is keeping up with required minor repairs. Desired Trend: ↓	The total number increasing or one tail number with a great deal more than the others, look for: 1. Actions being deferred for convenience or 2. Crew chiefs follow-up on discrepancies awaiting parts (AWP) and shop chief awareness of backlogs.

VII. Appendix "B". Description of Key Maintenance Metrics (AFLMA, 2002)

Flying Scheduling Effectiveness (FSE) Rate: This indicator is a measure of how well the unit planned and executed the weekly flying schedule. *Plan what you fly and fly what you plan* is still valuable flying schedule-guidance. Sticking to the printed schedule reduces turmoil, which helps keep people focused, allows for a better maintenance product, eases personnel tension, and stabilizes morale. It also drives more thoughtful and careful planning. A high FSE rate indicates the unit has planned well and executed the schedule. A low FSE rate may indicate needless turbulence; however, not all turbulence is bad. When intentionally introduced to avoid additional turbulence later, it is smart management. Otherwise, it is nothing but added pain for the unit. It is all too easy to get drawn into operations requirements versus maintenance capabilities when looking at causes of turbulence. The mission is priority number one all the time, but firm scheduling discipline is a must for effective operations. When the rate is low, leaders must search for opportunities to plan more carefully or stick to the current plan. Review chargeable deviations (situations generally within a unit's control) because they cause FSE to decrease. Ground aborts are the primary driver. A high commitment rate may also be influencing FSE. The FSE rate is a valuable indicator because it takes into account total unit performance. Some of the factors affecting FSE rates are timely aircraft preparation and repair, quality of maintenance, sense of urgency, crew-show discipline, avoidance of early and late takeoffs, and flexibility when unplanned events arise.

$$FSE\ Rate = \frac{\text{Adjusted Sorties Scheduled - Chargeable Deviations}}{\text{Adjusted Sorties Scheduled}} * 100$$

Flying Schedule Deviations: These are reasons why an aircraft didn't fly a sortie as scheduled and are recorded as chargeable or nonchargeable for activity causing deviation (operations, logistics, air traffic control, weather, higher headquarters, and so forth).

$$Ma\text{int}enance\ Rate = \frac{\text{Maintenance Deviations}}{\text{Total Sorties Scheduled}} * 100$$

$$Operations\ Rate = \frac{\text{Operations Deviations}}{\text{Total Sorties Scheduled}} * 100$$

Average Sortie Duration (ASD): This is the average time an aircraft stays airborne during an individual sortie. This number is normally computed monthly but can be done weekly. The computation is straightforward: total hours flown divided by total sorties flown.

Sortie UTE Rate (Lagging): This key indicator, particularly, for fighters serves as a yardstick for how well the maintenance organization supports the unit's mission. If the unit isn't meeting the sortie UTE rate, it means the average number of sorties per aircraft (based on average number of aircraft possessed (PAI), not on assigned aircraft) is lower than programmed. Just scheduling more sorties is not the answer. The root cause of a low UTE rate may lie in maintenance scheduling practices that result in low aircraft availability, effectiveness of the production effort that repairs and prepares aircraft for the next sortie, or even availability of qualified and trained technicians. It may also mean that other factors, such as weather, have an effect on the operation.

$$Sortie\ \text{UTE}\ Rate = \frac{\text{Sorties Flown}}{\text{Primary Aircraft Inventory}}$$

Hourly UTE Rate (Lagging): Operations and maintenance share this indicator because it reflects their combined performance. Operations is not flying the programmed ASD if

the unit does not meet the hourly UTE rate. When maintenance meets the sortie UTE rate and operations meets the hourly UTE rate, the squadron can successfully execute the annual flying-hour program.

$$\textit{Hourly}\ \text{UTE}\ \textit{Rate} = \frac{\text{Hours Flown}}{\text{Primary Aircraft Inventory}}$$

Abort Rate (Leading): A unit's abort rate can be an indicator of both aircraft reliability and quality of maintenance performed. The MAF tracks materiel and nonmateriel aborts through the Global Decision Support System and AMC History System via diversion codes J and K. A J divert is an abort due to an aircraft system malfunction, while a K divert is for nonmaterial reasons. Examine the abort rate in relation to system malfunctions. Look for trends, root causes, and lasting corrective actions. The focus should be on preventing as many aborts as possible. Adding a preventable or not preventable indicator on the chargeable deviations slide focuses attention on prevention. A high abort rate will drive the FSE rate down. An air abort is really an operations call. Not all airborne malfunctions, however, result in an air abort. If an alternate mission is flown, then it's not an air abort. If there are a lot of air aborts, talk with operations—it may simply be a misunderstanding of the rules.

$$\text{Abort}\ \textit{Rate} = \frac{\text{Air Aborts (J - Diverts)} + \text{Local Training Aborts} + \text{Ground Aborts}}{\text{Total Sorties Attempted}} * 100$$

$$\text{Total Sorties Attempted} = \text{Sorties Flown} + \text{Ground Aborts}$$

Code 3 Break Rate (Leading): The break rate is the percentage of sorties that land in a Code 3 status. It's an indicator of aircraft system reliability and, sometimes, a measure of the quality of aircraft maintenance performed. The break rate is also an excellent

predictor of parts demand. Several indicators that follow break rate are MC, TNMCS, CANN, and R/R.

$$\text{Code - 3 Break Rate} = \frac{\text{\# Sorties that Land Code - 3}}{\text{Sorties Flown}} * 100$$

Fully Mission Capable (FMC) Rate (Lagging): Compare the FMC rate with the monthly MC rate. A significant difference between the two indicates aircraft are flying with key systems partially inoperative and cannot perform all the designed operational capability statement missions. A low FMC rate may indicate a persistent parts-supportability problem.

$$\text{FMC Rate} = \frac{\text{FMC Hours}}{\text{Possessed Hours}} * 100$$

Mission Capable (MC) Rate: The MC rate is perhaps the best-known yardstick for measuring a unit's performance. This rate is very much a composite metric. That is, it is a broad indicator of many processes and metrics. A low MC rate may indicate a unit is experiencing many hard (long fix) breaks that don't allow them to turn an aircraft for many hours or several days. It may also indicate serious parts supportability issues, poor job prioritization, lack of qualified technicians, or poor sense of urgency. The key here is to focus on the negative trends and top system problems that lower the MC rate. Examining the 8-hour (fighter) or 12-hour (all other aircraft) fix rates may provide clues to a low MC rate, but be careful here—the message units should hear from leadership is, fixing aircraft well is more important than fixing aircraft fast. Positive trends for a well-managed fix rate will indicate good management. Fixes on some systems predictably take longer than 8 or 12 hours. Exceeding this mark is not necessarily indicative of poor

maintenance. However, a unit with poor production problems may consistently exceed 8-/12-hour fixes in a wide variety of systems.

$$\text{MC Rate} = \frac{\text{FMC Hours} + \text{PMCB Hours} + \text{PMCM Hours} + \text{PMCS Hours}}{\text{Possessed Hours}} * 100$$

Total Non-Mission Capable Supply (TNMCS) Rate (Lagging): TNMCS is driven principally by spare parts availability. However, maintenance can keep the rate lower by consolidating feasible CANNs to as few aircraft as practical. TNMCS is based on the number of airframes out for parts, instead of the number of parts that are MICAP. It does not take long to see the link between the CANN rate and TNMCS rate. The best situation is for both rates to be as low as possible. Another word of caution here—TNMCS should not be held low at the expense of increased CANN actions. Maintenance should not be driven to make undesirable CANNs (those that may be labor intensive or risk damaging the good part) just to keep the TNMCS rate low. Maintainers will let leaders know what they think if pressed to CANN a part that’s not feasible just to consolidate all MICAPs on one aircraft. An easy mistake is just looking at the few components eating up huge chunks of time. Usually these are hard-to-obtain items across the Air Force or involve heavy maintenance. They are obvious, but little can be done about them. Try focusing on the items getting a lot of hits. They may be easy to get, but why are so many being ordered? Is the base-stockage level high enough? Is there a trend or reason why so many need to be ordered in the first place? Another facet is the amount of time lost due to parts in transit. Are the parts easy to procure but sitting on pallets at some port? Are the folks

on base getting the old parts turned in? Could the part be fixed on base, even though the current guidance says send it back to the depot?

$$\text{TNMCS Rate} = \frac{\text{NMCS Hours} + \text{NMCB Hours}}{\text{Possessed Hours}} * 100$$

Repeat Recur (R/R) Rate: R/R is perhaps the most important and accurate measure of the quality of maintenance performed in a unit. A repeat discrepancy is one occurring on the same system or subsystem on the first sortie or sortie attempt after originally reported. A recurring discrepancy occurs on the second through fourth sortie or attempted sortie after the original occurrence. A unit's goal should be no R/Rs. A high R/R rate may indicate lack of thorough troubleshooting; inordinate pressure to commit aircraft to the flying schedule for subsequent sorties; or a lack of experienced, qualified, or trained technicians. Examine each R/R discrepancy and seek root causes and lasting fixes.

$$\text{R/R Rate} = \frac{\text{Total Repeats} + \text{Total Recurs}}{\text{Total Pilot Reported Discrepancies}} * 100$$

Eight-Hour Fix Rate (Leading): This indicator (the cumulative percentage of Code 3 aircraft breaks recovered within 8 hours of landing) shows how well the repair process is being managed. Occasionally, some repairs, just by their nature, exceed the standard timeframe. However, all repairs exceeding the standard time should be reviewed. This interval is used for fighter aircraft.

$$\text{8-hour Fix Rate} = \frac{\text{\# of Code-3 Breaks Fixed within 8 Hours After Landing}}{\text{Total Code-3 Breaks}} * 100$$

Maintenance Scheduling Effectiveness (MSE) Rate: MSE is a measure of maintenance's ability to plan and complete inspections and periodic maintenance. A low

MSE rate may indicate a unit is experiencing turbulence. It’s a leadership issue if the turbulence could be avoided with careful planning. When maintenance misses a scheduled action because an aircraft is broken off station, that’s a reasonable occurrence. When maintenance misses a scheduled action because the aircraft is pulled to support the flying program, beware. A unit should schedule maintenance first and then support the flying schedule with the remaining aircraft available. Too often, units do it the other way around—schedule maintenance with airframes left over after schedulers fill the flying schedule.

$$\text{MSE Rate} = \frac{\text{\# of Completed Scheduled Maintenance Actions}}{\text{\# of Maintenance Actions Scheduled}} * 100$$

Phase Flow: A phase time-distribution interval (TDI) is a product that shows hours remaining until the next phase on a flying squadron’s fleet. It is common practice to convert the TDI to a scatter diagram, facilitating ease of tracking. A perfect phase flow portrays a fleet’s evenly paced progression into phase (a nearly perfect diagonal line). Average phase time remaining on a fleet should be approximately half the inspection interval. However, a unit may have good reasons to manage its phase flow so the data points define a pattern other than a diagonal line. For example, in preparation for a long-distance overseas deployment, a unit may need to build up the average phase time remaining on its fleet, because phase capability may be limited for a short time. Beware of gaps or groupings, especially on aircraft with less than half the time remaining to phase.

Cann Rate (Lagging): The CANN rate is the average number of CANN actions per 100 sorties flown. A CANN action is the removal of a serviceable part from an aircraft or

engine to replace an unserviceable part on another aircraft or engine, or removal of a serviceable part to put into a readiness spares package for deployments. This rate includes all aircraft-to-aircraft and engine-to-aircraft CANN actions. The measurement is used in conjunction with the supply issue effectiveness rate. In most cases, a CANN action takes place when base supply cannot deliver the part when needed and mission requirements demand the aircraft be returned to an MC status. Since supply relies on the depot for replenishment, this indicator can also be used, in part, to indicate depot support.

$$\text{Cann Rate} = \frac{\text{\# of Aircraft - to - Aircraft Canns} + \text{\# of Engine - to - Aircraft Canns}}{\text{Total Sorties Flown}} * 100$$

VIII. Appendix "C". 1ST Solicitation Email Message to Cooperate in Survey

Dear Sir/Madam,

An important study is being conducted to compare maintenance scheduling philosophies and your expertise can be of great value to the research. What we would like to ask you is to give us your candid, honest, experienced opinion of the most commonly used aircraft scheduling philosophies and the most important performance metrics that capture the long term health of the fleet. We have a questionnaire that we would like you to answer and that will take **less than twenty minutes** of your valuable time to answer.

With your help, some of the important maintenance scheduling philosophies will be identified (i.e. **flying one "go" on Fridays, minimizing flying window** etc) and will be compared against various important metrics. The goal is to identify the maintenance scheduling philosophy that best improves the long term health of the fleet and improves maintenance effectiveness to meet unit sortie production goals; hopefully, **making your job easier and more effective**. We would like your cooperation in helping us achieve this goal.

The survey will take place in October and November and will involve three rounds of responses. Each round will build upon the previous and you will be able to see how the responses are affecting the outcomes. F-16 experience is beneficial though not a prerequisite for answering the questionnaires.

We would appreciate your cooperation in answering the questionnaires. If you are willing to cooperate, please reply to this email (you can click "Yes" at the voting buttons above), and we will contact you with details on how you can take the **web-based** questionnaire in the October - November timeframe.

Thank you for your courtesy of your assistance.

Very sincerely yours,

Konstantinos Iakovidis, Major, HAF | John Bell, Major, USAF

AFIT Student | Assistant Professor of Logistics Management

Graduate Logistics Management

IX. Appendix "D". Survey Approval from AFRL/HEH

DEPARTMENT OF THE AIR FORCE
AIR FORCE RESEARCH LABORATORY (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

20 October 2004

MEMORANDUM FOR AFIT/ENV
ATTN: K. Iakovidis

FROM: AFRL/HEH

SUBJECT: Approval for the Use of Volunteers in Demonstrations

1. Human experimentation as described in Protocol 05-04-E "Comparing F-16 Maintenance Philosophies" may begin.

2. In accordance with AFI 40-402, this protocol was reviewed and approved by the Wright Site Institutional Review Board (WSIRB) on 14October 2004, the AFRL Chief of Aerospace Medicine on 18 October 2004.

3. Please notify the undersigned of any changes in procedures prior to their implementation. A judgment will be made at that time whether or not a complete WSIRB review is necessary.

Signed 20 October 2004
HELEN JENNINGS
Human Use Administrator

X. APPENDIX "E". Survey Approval from AFPC/DPAFFA

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE PERSONNEL CENTER
RANDOLPH AIR FORCE BASE TEXAS

17 NOVEMBER 2004

MEMORANDUM FOR MAJ KONSTANTINOS IAKOVIDIS

FROM: AFPC/DPAFFA

SUBJECT: Request for Survey Approval

We have reviewed the Comparing F-16 Maintenance Philosophies Questionnaire and approved its use with students assigned to AFIT at Wright Patterson AFB. We have assigned a Survey Control Number (SCN) of USAF SCN 04-112. Assignment of this SCN is contingent upon the following modifications.

1. Ref 3c through 3j: Rephrase these items to read "How long (in minutes) is the ..."

The survey is valid through 31 May 2005. Please ensure that the SCN and expiration date appear within the survey, survey instructions or appropriate web site.

With regard to the survey and its associated results, it is important to draw your attention to the provisions of the Freedom of Information Act (FOIA). Under the FOIA, the public can request the results of your survey. Furthermore, if the results will be released outside the Air Force, please follow proper approval procedures through Public Affairs before the results are released.

Questions or concerns can be directed to me at DSN 665-2448 or louis.datko@randolph.af.mil. We wish you much success with your data collection effort.

Louis M. Datko

LOUIS M. DATKO
Chief, Air Force Survey Program

XI. Appendix "F". Initial Questionnaire of the Delphi Study

Comparing F-16 Maintenance Philosophies

Researcher: Maj Konstantinos Iakovidis AFIT/ENS/GLM
Advisor: Maj John Bell AFIT/ENS
Sponsor: 354 AMXS/CC, Eielson AFB

This 3-part Delphi survey is seeking for answers about:

1. The most commonly used scheduling philosophies that need to be compared in terms of improving the long term health of the fleet. In subsequent surveys you will be asked to rank initial responses.

2. The important performance metrics that capture the long term health of the fleet and the maintenance effectiveness to meet unit sortie production goals. In subsequent surveys you will be also asked to rank initial responses.

3. Specific **peace-time** durations that will be used as model input variables.

Your time answering the questionnaire is greatly appreciated. Your answers will help in identifying which are the commonly used F-16 unit maintenance scheduling philosophies that need to be compared in terms of improving the long term health of the fleet, which are the important performance metrics that capture long term health of the fleet and maintenance effectiveness to meet unit sortie production goals, and which are the values in various model input variables.

1. Commonly used F-16 unit scheduling philosophies.

In this section the most commonly used scheduling philosophies that need to be compared in terms of improving the long term health of the fleet will be identified. Current survey will utilize qualitative format while subsequent surveys will ask for ranking the initial proposals.

1a.: Please identify the most commonly used scheduling philosophies that need to be compared in terms of improving the long term health of the fleet. For example, flying only one wave on Fridays if operational requirements are met, minimize the flying window, the more you fly an aircraft the more reliable it is, etc.

Please write your answer in the box below:

2. Important performance metrics

In this section the most important performance metrics to capture long term health of the fleet and maintenance effectiveness to meet unit sortie production goals will be identified. Current survey will utilize qualitative format while subsequent surveys will ask for ranking the initial proposals.

2a.: Please identify the important performance metrics that capture the long term health of the fleet. You can propose any metric (either used by USAF or not) that you think that captures fleet health. Please, explain your proposal.

Please write your answer in the box below:

2b.: Please identify the important performance metrics that capture the maintenance effectiveness to meet unit sortie production goals. You can propose any metric (either used by USAF or not) that you think that captures maintenance effectiveness. Please, explain your proposal.

Please write your answer in the box below:

3. F-16 specific - those without F-16 experience please do not answer

In this section, some of the model input variables will be identified.

3a.: How many years of F-16 maintenance experience do you have?

Please write your answer here:

3b.: Have you ever been assigned to Eielson AFB?

Please tick **only one** of the following:

- ☐ Yes
- ☐ No

3c.: How long (in minutes) is the typical refueling time for F-16's?

Please write your answer here:

3d.: How long (in minutes) is the typical duration of weapons preparation?

Please write your answer here:

3e.: How long (in minutes) is the typical duration of preflight?

Please write your answer here:

3f.: How long (in minutes) is the typical duration of F-16 launch?

Please write your answer here:

3g.: How long (in minutes) is the typical duration of taxiing in Eielson AFB?

Please write your answer here:

3h.: How long (in minutes) is the typical F-16 service time between flights?

Please write your answer here:

3i.: How long (in minutes) is the typical debrief time?

Please write your answer here:

3j.: How long (in minutes) is the typical time from land to park for Eielson AFB?

Please write your answer here:

3k.: How long (in minutes) is the typical duration for F-16 parking and recovery?

Please write your answer here:

3l.: How long (in minutes) is the typical duration for paper work after failures?

Please write your answer here:

XII. Appendix “G”. 2nd Round of the Delphi Study

2nd Round of Comparing F-16 Maintenance Philosophies

1. Commonly used F-16 unit scheduling philosophies.

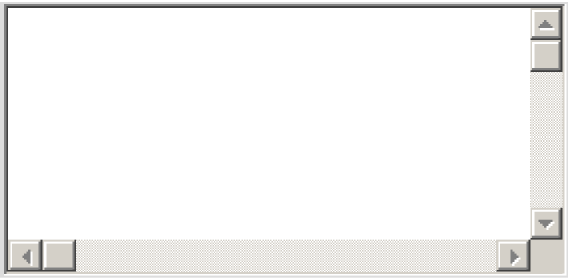
1a.: The following scheduling philosophies were identified by the initial round of the Delphi study. Please rank them in order starting from 1 (1 denotes the most significant philosophy that needs further testing). Please rank only your top 10 selection (no need to spend time in ranking the less significant philosophies).

Please number your top 10 philosophies in order of preference from 1 to 10 (1 denotes the most significant)

- [ ] "Balanced" approach of spreading the schedule out equally throughout the week/month
- [ ] 1 "large" wave on Fridays VS 2 "normal" waves
- [ ] 1 "normal" wave on Fridays VS 2 "normal" waves
- [ ] 2.5 hours between land - takeoff
- [ ] Adjusted turn patterns to accommodate fewer front lines
- [ ] At least 12 hours between last down and first go
- [ ] Don't keep a plane down more that 30 days
- [ ] Ensure enough downtime for scheduled and unscheduled maintenance
- [ ] Extended VS condensed flying window
- [ ] Fly heavy at the beginning of the fiscal year and let off later
- [ ] Increase Average Sortie Duration (ASD)
- [ ] Keep UTE rate under certain level
- [ ] Minimize the number of configurations
- [ ] No cann birds for sake of MC Rate
- [ ] No-fly Fridays
- [ ] Pit and Go daily VS two to three times per week
- [ ] Schedule more sorties at night to allow more robust day shifts
- [ ] Sortie Surge once per month VS once per quarter
- [ ] The more the aircraft flies the more reliable it is

1b.: Please explain your rationale for how you ranked your top five maintenance philosophies in question 1a.

Please write your answer in the box below:



2a.: The following performance metrics that capture the long term health of the fleet were identified by the 1st round of the Delphi study. Please rank them starting from 1 (1 denotes the most significant metric). Please rank only your top 10 selection (no need to spend time in ranking the less significant metrics).

Please number your top 10 metrics in order of preference from 1 to 10 (1 denotes the most significant)

- [ ] % of scheduled sorties that accomplished full mission objectives
- [ ] Amount of time taken to complete Depot Maintenance
- [ ] Break Rate
- [ ] Cann rate
- [ ] Ground Abort Rate
- [ ] Maintenance discrepancy fix rates
- [ ] Maintenance Scheduling Effectiveness Rate
- [ ] Maintenance Non Deliverables (MND)
- [ ] MC Rate
- [ ] Number and type of exceptional write-ups
- [ ] Number of discrepancies during phase inspections
- [ ] Number of K write-ups - Delayed Discrepancies
- [ ] Phase Flow Days
- [ ] Phase Time Distribution Interval
- [ ] Repeat/Recur Rate
- [ ] TCTO Backlog
- [ ] Time each aircraft spends broken
- [ ] TNMCM
- [ ] UTE rate

2b.: Please explain your rationale for how you ranked your top five performance metrics in question 2a.

Please write your answer in the box below:

3a.: The following performance metrics that capture maintenance effectiveness and the ability to meet unit sortie production goals were identified by the 1st round of the Delphi study. Please rank them starting from 1 (1 denotes the most significant metric). Please rank only your top 10 selection (no need to spend time in ranking the less significant metrics).

Please number your top 10 metrics in order of preference from 1 to 10 (1 denotes the most significant)

- [ ] (Number of ac scheduled for the day's flying schedule) / (Number FMC ac) 2 hours prior first launch
- [ ] Cann rate
- [ ] Comparison of number of schedule change requests to number accepted/rejected/accomplished
- [ ] Discrepancies awaiting maintenance (AWM)
- [ ] Fix Rates
- [ ] Flying scheduling effectiveness rate
- [ ] Ground abort rates
- [ ] Maintenance discrepancy fix rates
- [ ] MC Rate
- [ ] Mission Success Rate
- [ ] On-time departure rates
- [ ] Phase backlog
- [ ] Phase time completion stats
- [ ] Repeat/Recur Rate
- [ ] Schedule "fill" rates
- [ ] Sortie completion rate
- [ ] TNMCM

3b.: Please explain your rationale for how you ranked your top five performance metrics in question 3a.

Please write your answer in the box below:

4.: Please provide with any comments you may have about this survey.

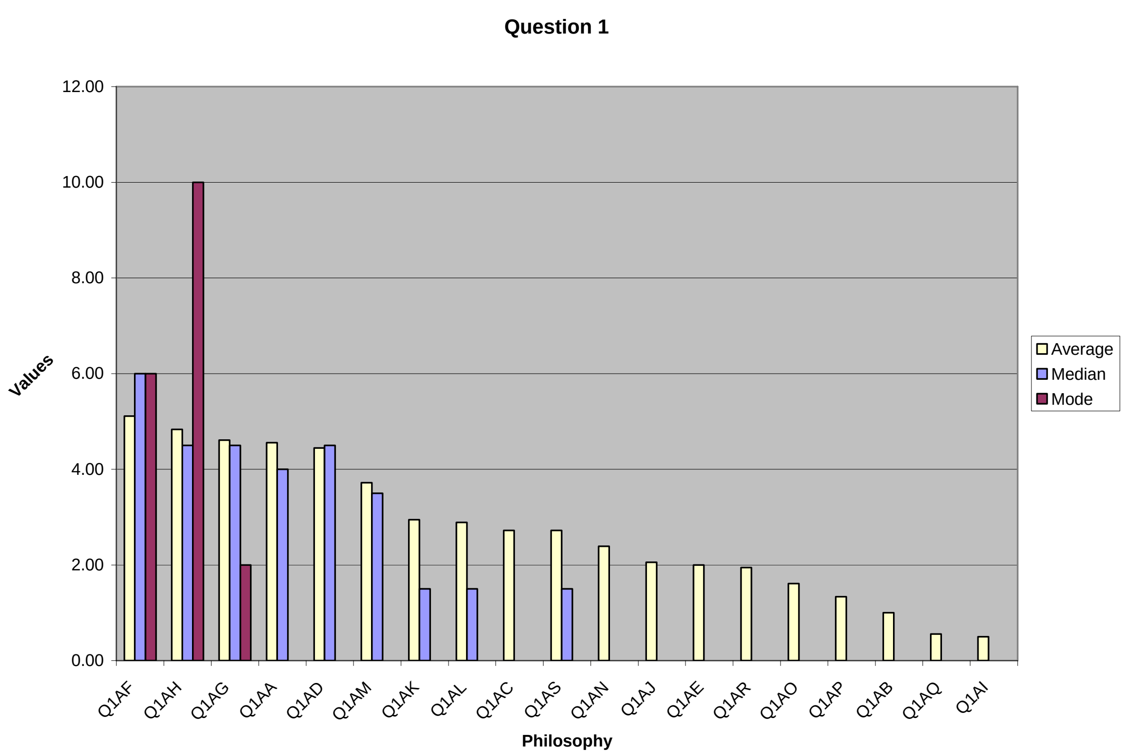
Please write your answer in the box below:

XIII. Appendix "H". 3rd Round of the Delphi Study

SECTION I: COMMONLY USED F-16 UNIT SCHEDULING PHILOSOPHIES

Below are the results of the second round of the Delphi study regarding the most significant maintenance scheduling philosophies that need further study. If you can recall from the second round, you were asked to rank your top-10 selection (10 denoting the most significant philosophy). Unselected philosophies were assumed to have a grade of zero. Three proxy values are used and illustrated in the graph:

Mean (average): The sum of rankings divided by the number of responses. Higher average means that many of the respondents selected this philosophy in their top list and usually in their Top-5. Data are presented in descending average order.
Median: The middle number when the grades are arranged in ascending order. Because the nine (19 total minus 10 selected) unselected philosophies for each response were assigned zero-grade, higher median denotes that most of the respondents selected the corresponding philosophy in their Top-10.
Mode: The ranking order that occurred most frequently in the responses. This is usually zero because the nine (19 total minus 10 selected) unselected philosophies for each response were assigned zero-grade; if it is not, it gives good insight for what most of the respondents think about the corresponding philosophy.



Q1AF: At least 12 hours between last down and first go
Q1AH: Ensure enough downtime for scheduled and unscheduled maintenance
Q1AG: Don't keep a plane down more than 30 days
Q1AA: "Balanced" approach of spreading the schedule out equally throughout the week/month
Q1AD: 2.5 hours between land - takeoff
Q1AM: Minimize the number of configurations
Q1AK: Increase Average Sortie Duration (ASD)
Q1AL: Keep UTE rate under certain level
Q1AC: 1 "normal" wave on Fridays VS 2 "normal" waves
Q1AS: The more the aircraft flies the more reliable it is
Q1AN: No cann birds for sake of MC Rate
Q1AJ: Fly heavy at the beginning of the fiscal year and let off later
Q1AE: Adjusted turn patterns to accommodate fewer front lines
Q1AR: Sortie surge once per month VS once per quarter
Q1AO: No-fly Fridays
Q1AP: Pit and Go daily VS two to three times per week
Q1AB: 1 "large" wave on Fridays VS 2 "normal" waves
Q1AQ: Schedule more sorties at night to allow more robust day shifts
Q1AI: Extended VS condensed flying window

QUESTION: Do you agree with the TOP-5 maintenance scheduling philosophies (in bold format above)? If no, please provide your rationale.

YES NO

If no, please explain:

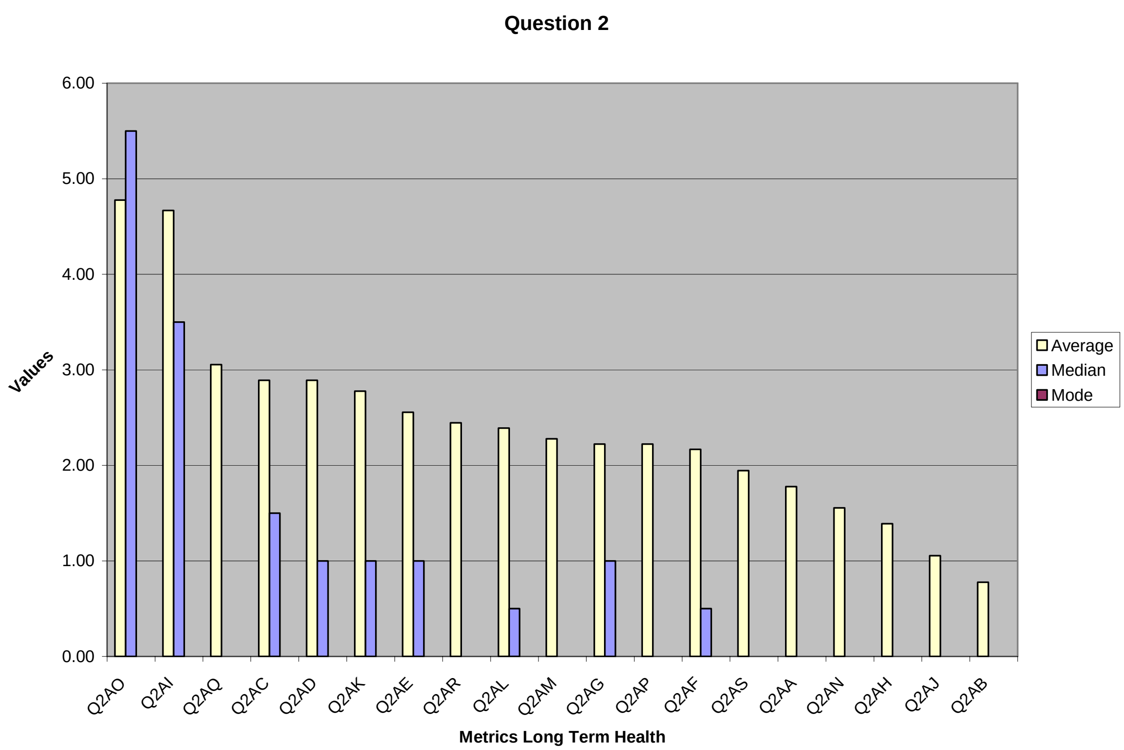
SECTION II: PERFORMANCE METRICS THAT CAPTURE THE LONG TERM HEALTH OF THE FLEET

Below are the results of the second round of the Delphi study regarding the most significant metrics that capture the long term health of the fleet. If you can recall from the second round, you were asked to rank your top-10 selection (10 denoting the most significant metric). Unselected metrics were assumed to have a grade of zero. Three proxy values are used and illustrated in the graph:

Mean (average): The sum of rankings divided by the number of responses. Higher average means that many of the respondents selected this metric in their top list and usually in their Top-5. Data are presented in descending average order.

Median: The middle number when the grades are arranged in ascending order. Because the nine (19 total minus 10 selected) unselected metrics for each response were assigned zero-grade, higher median denotes that most of the respondents selected the corresponding metric in their Top-10.

Mode: The ranking order that occurred most frequently in the responses. This is usually zero because the nine (19 total minus 10 selected) unselected metrics for each response were assigned zero-grade; if it is not, it gives good insight for what most of the respondents think about the corresponding metric.



Q2AO: Repeat / Recur Rate
Q2AI: MC Rate
Q2AQ: Time each aircraft spends broken
Q2AC: Break rate
Q2AD: Cann Rate
Q2AK: Number of discrepancies during phase inspections
Q2AE: Ground Abort Rate
Q2AR: TNMCM
Q2AL: Number of K write-ups – Delayed Discrepancies
Q2AM: Phase Flow Days
Q2AG: Maintenance Scheduling Effectiveness Rate
Q2AP: TCTO Backlog
Q2AF: Maintenance discrepancy fix rates
Q2AS: UTE Rate
Q2AA: % of scheduled sorties that accomplished full mission objectives
Q2AN: Phase Time Distribution Interval
Q2AH: Maintenance Non-Deliverables
Q2AJ: Number and type of exceptional write-ups
Q2AB: Amount of time taken to complete Depot Maintenance

QUESTION: Do you agree with the TOP-5 metrics that capture the long-term health of the fleet (in bold format above)? If no, please provide your rationale.

YES NO

If no, please explain:

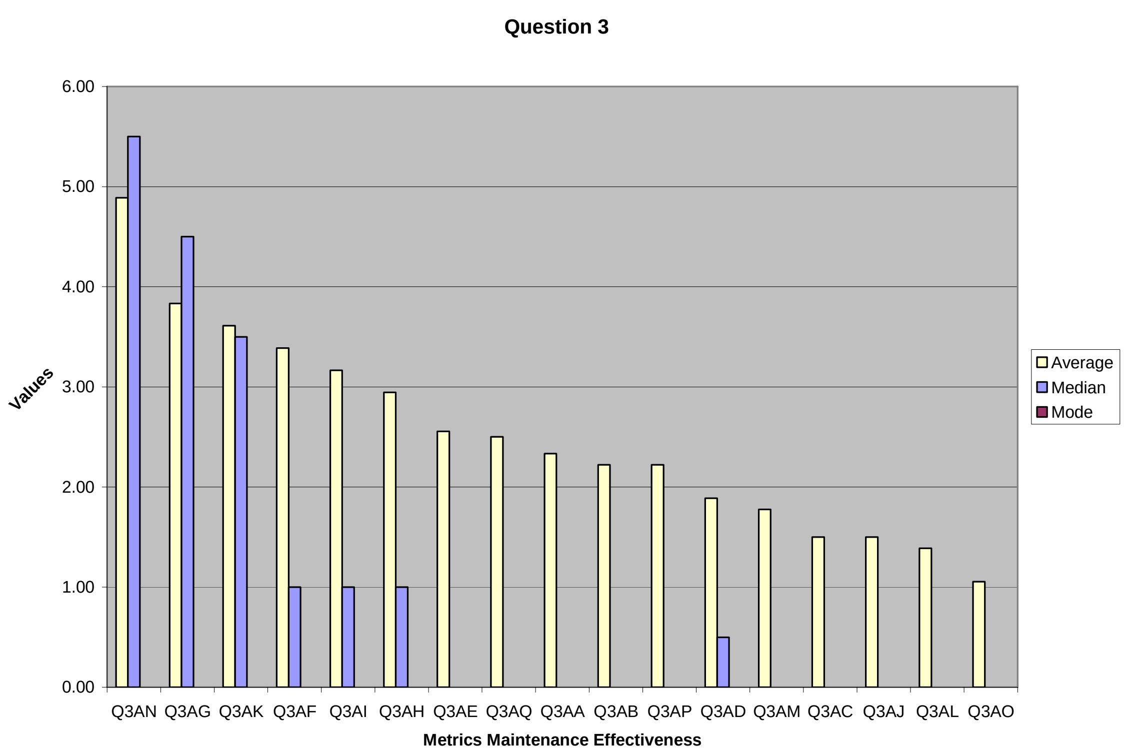
SECTION II: PERFORMANCE METRICS THAT CAPTURE MAINTENANCE EFFECTIVENESS AND THE ABILITY TO MEET UNIT SORTIE PRODUCTION GOALS

Below are the results of the second round of the Delphi study regarding the most significant metrics that capture the maintenance effectives and the ability to meet unit sortie production goals. If you can recall from the second round, you were asked to rank your top-10 selection (10 denoting the most significant metric). Unselected metrics were assumed to have a grade of zero. Three proxy values are used and illustrated in the graph:

Mean (average): The sum of rankings divided by the number of responses. Higher average means that many of the respondents selected this metric in their top list and usually in their Top-5. Data are presented in descending average order.

Median: The middle number when the grades are arranged in ascending order. Because the seven (17 total minus 10 selected) unselected metrics for each response were assigned zero-grade, higher median denotes that most of the respondents selected the corresponding metric in their Top-10.

Mode: The ranking order that occurred most frequently in the responses. This is usually zero because the seven (17 total minus 10 selected) unselected metrics for each response were assigned zero-grade; if it is not, it gives good insight for what most of the respondents think about the corresponding metric.



Q3AN: Repeat / Recur Rate
Q3AG: Ground abort rate
Q3AK: On-time departure rates
Q3AF: Flying scheduling effectiveness rate
Q3AI: MC Rate
Q3AH: Maintenance discrepancy fix rates
Q3AE: Fix rates
Q3AQ: TNMCM
Q3AA: (Number of ac scheduled for the day's flying schedule) / (Number FMC ac) 2 hours prior first launch
Q3AB: Cann rate
Q3AP: Sortie completion rate
Q3AD: Discrepancies awaiting maintenance (AWM)
Q3AM: Phase time completion stats
Q3AC: Comparison of number of schedule change requests to number accepted / rejected / accomplished
Q3AJ: Mission Success Rate
Q3AL: Phase backlog
Q3AO: Schedule "fill" rates

QUESTION: Do you agree with the TOP-5 metrics that capture maintenance effectiveness to meet sortie production goals (in bold format above)? If no, please provide your rationale.

YES NO

If no, please explain:

SECTION IV: FINAL COMMENTS

Please provide any additional comments you may have.

XIV. Appendix "I". Failure Data Analysis from Eielson AFB

Introduction

Several data were requested from Eielson AFB to be analyzed in order to estimate the appropriate model parameters. One year failure data were provided from Eielson AFB in text format. Sample of the data provided is illustrated in figure below.

```
TRIC:       UNIT: A                                                                                     DATE RANGE: 01OCT03 - 30SEP04

************************************************************************************************************************************

EVENT-ID          EQUIP ID          CP        WUC/LCN           WD      REP         REC         SYM         SORTIE NBR          EVT-ACT COMP
032730477            A0482          0       13HDF               B       0           0           /              000                30 OCT 03

DISCREPANCY: NOSE WOW SWITCH HEAT SHRINK REQUIRES REPAIR

WCE-SEQ              PWC              EQUIP ID            WUC/LCN            SYM           SRD            IN-SHOP              WCE-ACT COMP
  001               AFELE                               13HDF                              AKD              NO                   30 OCT 03

DDR-SEQ TM  CP     WUC/LCN       AT WD  HM MCC UP START DATE STOP    HRS  CS CLB CC-AI EMPL # AFSC     MDS   BLK SERIAL NBR SRD
  001    B  0  13HDF             X  B  799  C  01 1200 03303 1230    1.0   2  1        003472 2A656    F016C     8800000482 AKD

************************************************************************************************************************************

EVENT-ID          EQUIP ID          CP        WUC/LCN           WD      REP         REC         SYM         SORTIE NBR          EVT-ACT COMP
032890149            A0482          0       49                  B       0           0           -              000                06 NOV 03

DISCREPANCY: LOX INDICATOR GUAGE REQUIRES OP CHECK

WCE-SEQ              PWC              EQUIP ID            WUC/LCN            SYM           SRD            IN-SHOP              WCE-ACT COMP
  001               AFELE                               49                                 AKD              NO                   06 NOV 03

DDR-SEQ TM  CP     WUC/LCN       AT WD  HM MCC UP START DATE STOP    HRS  CS CLB CC-AI EMPL # AFSC     MDS   BLK SERIAL NBR SRD
  001    B  0  49ABA             H  B  799  C  01 0700 03310 0808    1.1   1  1        009886 2A373    F016C     8800000482 AKD

************************************************************************************************************************************

EVENT-ID          EQUIP ID          CP        WUC/LCN           WD      REP         REC         SYM         SORTIE NBR          EVT-ACT COMP
032890152            A0482          0       41A                 B       0           0           X              000                04 NOV 03

DISCREPANCY: HEAT EXCHANGER EXHAUST DUCT REMOVED TO FOM

WCE-SEQ              PWC              EQUIP ID            WUC/LCN            SYM           SRD            IN-SHOP              WCE-ACT COMP
  001               AFELE                               41A                                AKD              NO                   04 NOV 03

DDR-SEQ TM  CP     WUC/LCN       AT WD  HM MCC UP START DATE STOP    HRS  CS CLB CC-AI EMPL # AFSC     MDS   BLK SERIAL NBR SRD
  001    B  0  41AAL             S  B  800  C  01 1200 03308 1400    4.0   2  1        002831 2A636    F016C     8800000482 AKD

************************************************************************************************************************************

EVENT-ID          EQUIP ID          CP        WUC/LCN           WD      REP         REC         SYM         SORTIE NBR          EVT-ACT COMP
032890154            A0482          0       11                  B       0           0           X              000                03 NOV 03

DISCREPANCY: PANEL 3317 OPENED TO FOM
```

Figure 154. Text Format of Failure Data Provided by Eielson AFB

Text format needed to be converted in database format for manipulation. About 5000 records were in two text files that needed to be parsed. Two PHP Hypertext Preprocessor (PHP) scripts were written to parse the text files and reformat them in order to be in a database format. The first script (splitevents.php, Appendix "Q") separated each event (failure and corrective actions) in different text files and the second script

(parse.php, Appendix “R”) converted the text files into *.csv files for easy importing into Microsoft® Access® database.

Once the failures were entered into a database, it was easier to filter them in accordance with the Primary Working Center (PWC) and the “When Discovered Code, WD”. The one year failures can be categorized[19] as follows (Table 7):

Table 7. Failure Rates Calculation

Type of Failure	WD Code[20]	# failures	Total sorties	Failures per 100 sorties
Ground Abort	A	170	4470	3.80%
Air Abort	C	11	4470	0.24%
After flight failure	E, F, H, J	1699	4470	38.01%

These failures can further be categorized in accordance with the Primary Working Center (PWC) per Table 8:

Table 8. Failures per Primary Working Center

PWC	Ground Aborts	Air Aborts	After Flight Failures
APG	63	10	932
EandE	21	0	143
Avionics	66	0	395
Engine	11	1	160
Weapons	9	0	69
Total	170	11	1699

[19] Only the five more critical specialties were simulated per Eielson’s AFB input (APG, Electrical and Environmental, Avionics, Engine, and Weapons.

[20] When Discovered Codes: A: Before flight – Abort, C: In Flight – Abort, E: After flight, F: Between flights, H: Thruflight, J: Preflight or Combined Preflight/Postflight

Both the failure durations and the crew sizes for each failure were analyzed using Arena’s® Input Analyzer.

Theory behind Fitting Distributions

If historical data re present, a decision has to be made whether to use the data directly or whether to fit a probability distribution to the existing data. From a theoretical standpoint, the collected data represent what’s happened in the past, which may or may not be an unbiased prediction of what will happen in the future. If the conditions surrounding the generation of these historical data no longer apply, then the historical data may be biased or may simply be missing some important aspects of the process. In our case, it is assumed that the conditions surrounding the generation of these data will continue to exist so the theoretical distribution do not produce biased data.

Probability distributions can be thought of as falling into two main groups: theoretical and empirical. Theoretical distributions, such as the exponential and triangular, generate samples based on a mathematical formulation. Empirical distributions simply divide the actual data into groupings and calculate the proportion of values in each group, possibly interpolating between points for more accuracy.

Each type of distribution is further broken down into continuous and discrete types. The continuous distributions can return any real-valued quantity (within a range for the bounded types). The discrete distributions can return only integer-valued quantities. Arena’s® Input Analyzer can fit any of the above distributions to the analyzed data. By fitting a probability distribution, Input Analyzer will provide numerical estimates of the appropriate parameters, and suggest the most appropriate distribution and

its parameters based on the least mean square error (a measure of the quality of the distribution's match to the data). This is the average of the square error terms for each histogram cell, which are the squares of the differences between the relative frequencies of the observations in a cell and the relative frequency for the fitted probability distribution over that cell's data range. The larger this square error value, the further away the fitted distribution is from the actual data (and thus the poorer the fit).

There are two measures of a distribution's fit to the data: the chi-square and Kolmogorov-Smirnov (K-S) goodness-of-fit hypothesis tests. These are standard statistical hypothesis tests that can be used to assess whether a fitted theoretical distribution is a good fit to the data. The Input Analyzer reports information about the tests; of particular interest is the corresponding p-value which is the probability of getting a data set that's more inconsistent with the fitted distribution than the data set you actually got, if the fitted distribution is truly "the truth". To interpret this, larger p-values indicate better fits. Corresponding p-values less than about 0.05 indicate that the distribution is not a very good fit. A high p-value does not constitute "proof" of a good fit but just a lack of evidence against the fit.

The first critical decision in fitting distribution is whether to use a theoretical or an empirical one. Examining the results of the K-S and chi-square tests can be helpful. If the p-values for one or more distributions are fairly high (e.g., 0.10 or greater), then a theoretical distribution can be used with a fairly degree of confidence that a good representation of data is obtained. If the p-values are low, an empirical distribution should be used for better capturing the characteristics of the data. Based on the above information the failure durations and the crew sizes for each failure were analyzed.

Failure Data Analysis

For each PWC and each type of failure two different "Fit Distribution" tests were run: one for the failure duration itself and the other for the crew size that worked for the failures. Thirty different tests were run (3 failure types X 5 PWC X 2 tests) with the following results:

APG – Ground Abort – Duration.

The results after fitting all the distributions are presented in Figures 155 and 156. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is illustrated in Figures 157 and 158. The expression that was used in Arena for the duration of ground abort APG failures is:

CONT (0.000, 9.999, 0.714, 94.285, 0.841, 178.571, 0.905, 262.857, 0.952, 347.143, 0.984, 431.429, 0.984, 515.715, 0.984, 600.001, 1, 600.002)[21]

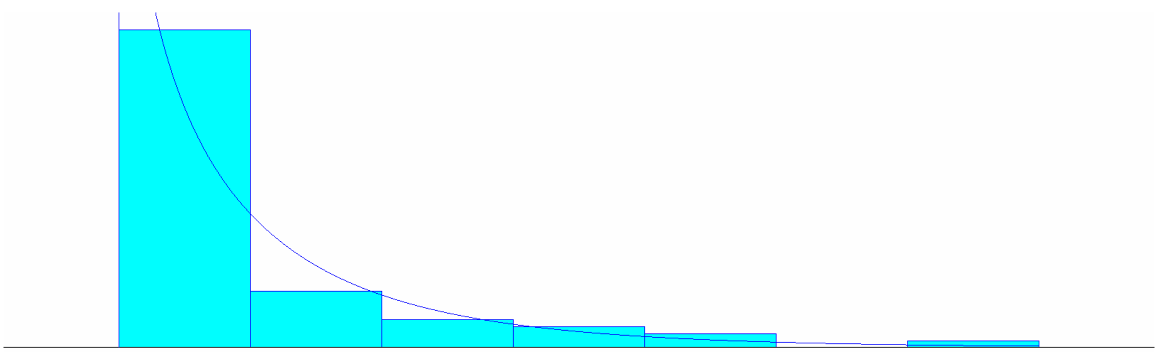


Figure 155. APG Ground Abort Duration

[21] The CONTINUOUS function in Arena returns a sample from a user defined empirical distribution. Pairs of cumulative probabilities and associated values are specified. The pair (1, 600.002) was manually added because the final cumulative probability has to be 1.

Distribution Summary

Distribution: Weibull
Expression: 10 + WEIB(78.6, 0.82)
Square Error: 0.008823

Chi Square Test
Number of intervals = 3
Degrees of freedom = 0
Test Statistic = 1.83
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.181
Corresponding p-value = 0.0288

Data Summary

Number of Data Points = 63
Min Data Value = 10
Max Data Value = 600
Sample Mean = 97
Sample Std Dev = 109

Histogram Summary

Histogram Range = 10 to 600
Number of Intervals = 7

Figure 156. APG Ground Abort Duration

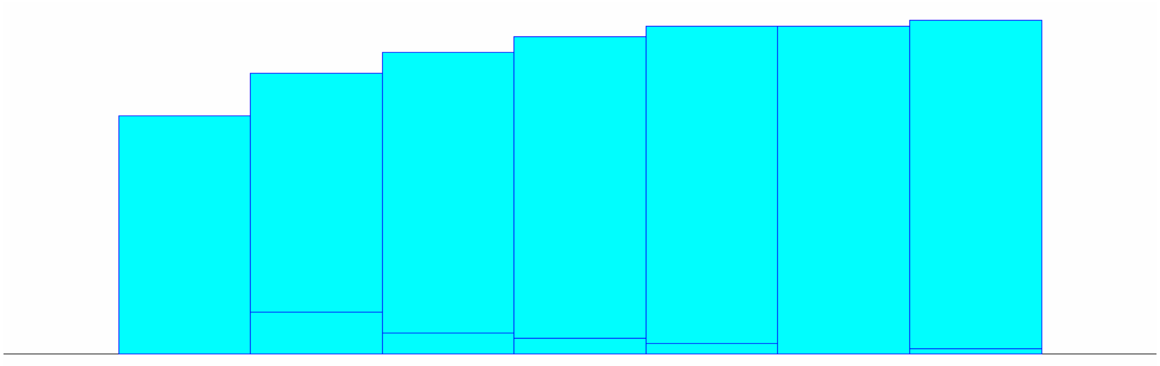


Figure 157. APG Ground Abort Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 9.999, 0.714, 94.285, 0.841, 178.571, 0.905, 262.857, 0.952, 347.143, 0.984, 431.429, 0.984, 515.715, 0.984, 600.001)

Data Summary

Number of Data Points	= 63
Min Data Value	= 10
Max Data Value	= 600
Sample Mean	= 97
Sample Std Dev	= 109

Histogram Summary

Histogram Range	= 10 to 600
Number of Intervals	= 7

Figure 158. APG Ground Abort Duration Empirical

APG – Ground Abort – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are

illustrated in Figures 159 and 160 and the expression that was used in Arena for the crew size of ground abort APG failures is:

DISC (0.159, 1, 0.952, 2, 1, 3)[22]

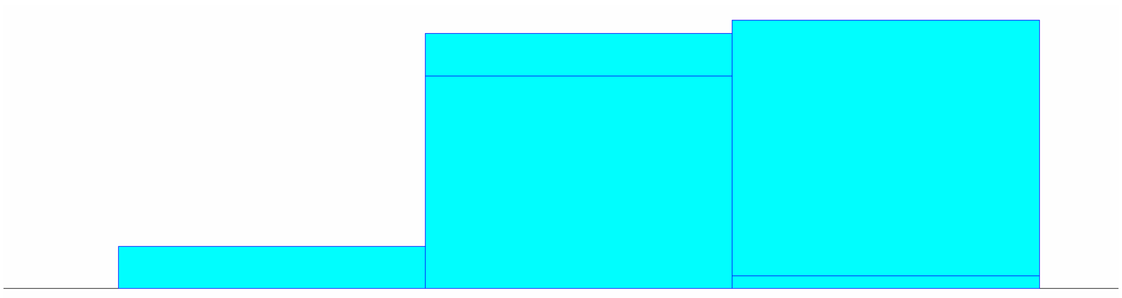


Figure 159. APG Ground Aborts Crew Size

Distribution Summary

Distribution: Empirical
Expression: DISC (0.000, 0.500, 0.159, 1.500, 0.952, 2.500, 0.952, 3.500)
DISC (0.159, 1, 0.952, 2, 1, 3)

Data Summary

Number of Data Points = 63
Min Data Value = 1
Max Data Value = 3
Sample Mean = 1.89
Sample Std Dev = 0.444

Histogram Summary

Histogram Range = 0.5 to 3.5
Number of Intervals = 3

Figure 160. APG Ground Aborts Crew Size

[22] The DISCRETE function in Arena returns a sample from a user defined discrete probability distribution. The distribution is defined by the set of n possible discrete values that can be returned by the function and the cumulative probabilities associated with these discrete values. By definition the last cumulative probability has to be equal to 1.

APG – Air Abort – Duration.

The results after fitting all the distributions are presented in Figures 161 and 162. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is illustrated in Figures 163 and 164. The expression that was used in Arena for the duration of air abort APG failures is:

CONT (0.000, 14.999, 0.500, 95.999, 0.500, 177.000, 0.700, 258.000, 0.700, 339.001, 0.700, 420.001, 1, 420,002)

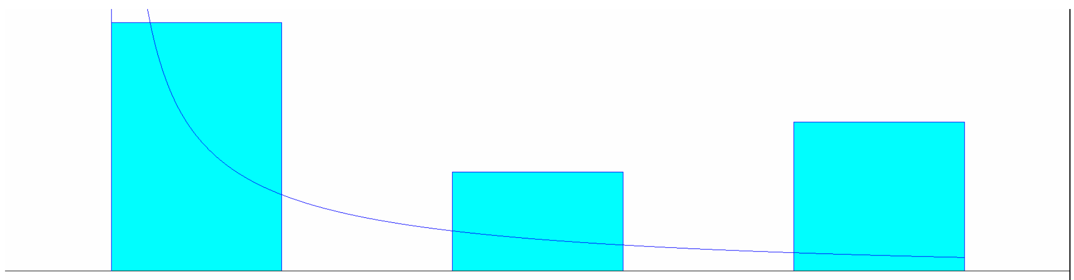


Figure 161. APG Air Aborts Duration

Distribution Summary
Distribution: Gamma
Expression: 15 + GAMM(585, 0.277)
Square Error: 0.113937
Kolmogorov-Smirnov Test
Test Statistic = 11.7
Corresponding p-value < 0.01
Data Summary
Number of Data Points = 10
Min Data Value = 15
Max Data Value = 420
Sample Mean = 177
Sample Std Dev = 165
Histogram Summary
Histogram Range = 15 to 420
Number of Intervals = 5

Figure 162. APG Air Aborts Duration

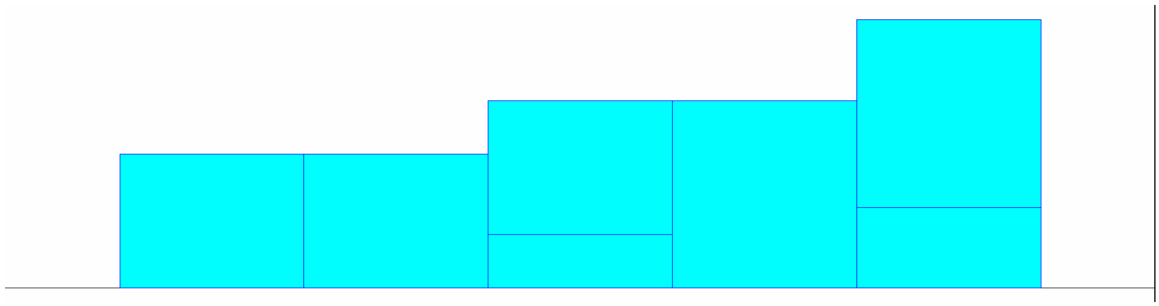


Figure 163. APG Air Aborts Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 14.999, 0.500, 95.999, 0.500, 177.000, 0.700, 258.000, 0.700, 339.001, 0.700, 420.001)

Data Summary

Number of Data Points	= 10
Min Data Value	= 15
Max Data Value	= 420
Sample Mean	= 177
Sample Std Dev	= 165

Histogram Summary

Histogram Range	= 15 to 420
Number of Intervals	= 5

Figure 164. APG Air Aborts Duration Empirical

APG – Air Aborts – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 165 and 166 and the expression that was used in Arena for the crew size of air abort APG failures is:

DISC (0.000, 1, 0.900, 2, 1, 3)

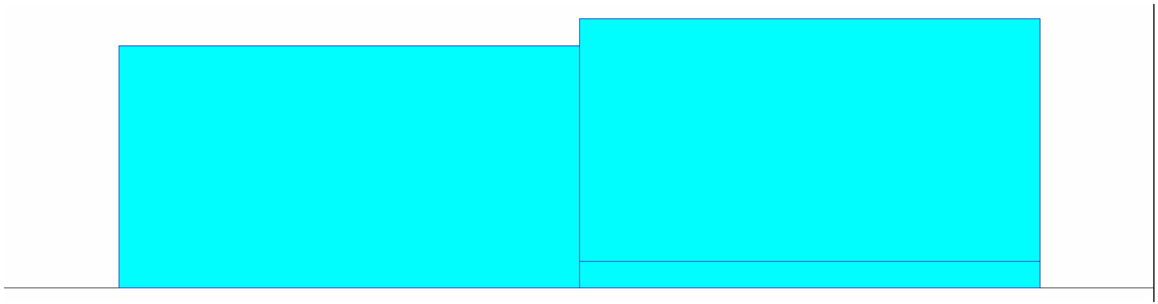


Figure 165. APG Air Aborts CS

Distribution Summary	
Distribution:	Empirical
Expression:	DISC (0.000, 1.500, 0.900, 2.500, 0.900, 3.500)
DISC (0.000, 1, 0.900, 2, 1, 3)	
Data Summary	
Number of Data Points	= 10
Min Data Value	= 2
Max Data Value	= 3
Sample Mean	= 2.1
Sample Std Dev	= 0.316
Histogram Summary	
Histogram Range	= 1.5 to 3.5
Number of Intervals	= 2

Figure 166. APG Air Aborts CS

APG – After Flight – Duration.

The results after fitting all the distributions are presented in Figures 167 and 168. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is illustrated in Figures 169 and 170. The expression that was used in Arena for the duration of after flight APG failures is shown in Figure 170:

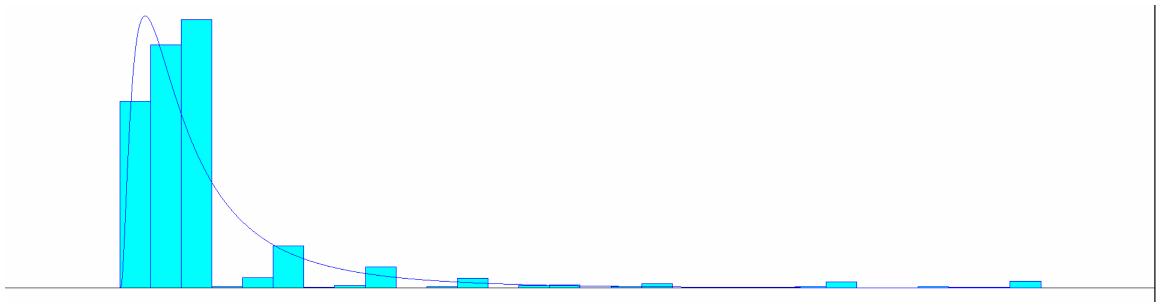


Figure 167. APG After Flight Duration

Distribution Summary	
Distribution:	Lognormal
Expression:	LOGN(62.2, 74.4)
Square Error:	0.040777
Chi Square Test	
Number of intervals	= 13
Degrees of freedom	= 10
Test Statistic	= 358
Corresponding p-value	< 0.005
Kolmogorov-Smirnov Test	
Test Statistic	= 0.152
Corresponding p-value	< 0.01
Data Summary	
Number of Data Points	= 932
Min Data Value	= 0.99
Max Data Value	= 600
Sample Mean	= 65
Sample Std Dev	= 91.1
Histogram Summary	
Histogram Range	= 0 to 600
Number of Intervals	= 30

Figure 168. APG After Flight Duration

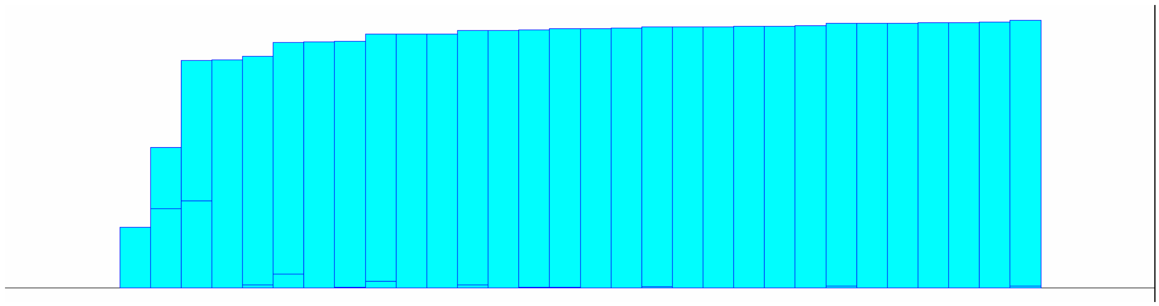


Figure 169. APG After Flight Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 0.000, 0.227, 20.000, 0.524, 40.000, 0.850, 60.000, 0.852, 80.000, 0.865, 100.000, 0.916, 120.000, 0.917, 140.000, 0.921, 160.000, 0.946, 180.000, 0.946, 200.000, 0.948, 220.000, 0.960, 240.000, 0.960, 260.000, 0.964, 280.000, 0.968, 300.000, 0.968, 320.001, 0.970, 340.001, 0.975, 360.001, 0.975, 380.001, 0.975, 400.001, 0.976, 420.001, 0.977, 440.001, 0.980, 460.001, 0.987, 480.001, 0.987, 500.001, 0.987, 520.001, 0.989, 540.001, 0.990, 560.001, 0.991, 580.001, 0.991, 600.001, 1, 600.002)

Data Summary

Number of Data Points = 932
Min Data Value = 0.99
Max Data Value = 600
Sample Mean = 65
Sample Std Dev = 91.1

Histogram Summary

Histogram Range = 0 to 600
Number of Intervals = 30

Figure 170. APG After Flight Duration Empirical

APG – After Flight – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are

illustrated in Figures 171 and 172 and the expression that was used in Arena for the crew size of after flight APG failures is:

DISC (0.000, 0, 0.305, 1, 0.944, 2, 0.991, 3, 0.998, 4, 1, 5)

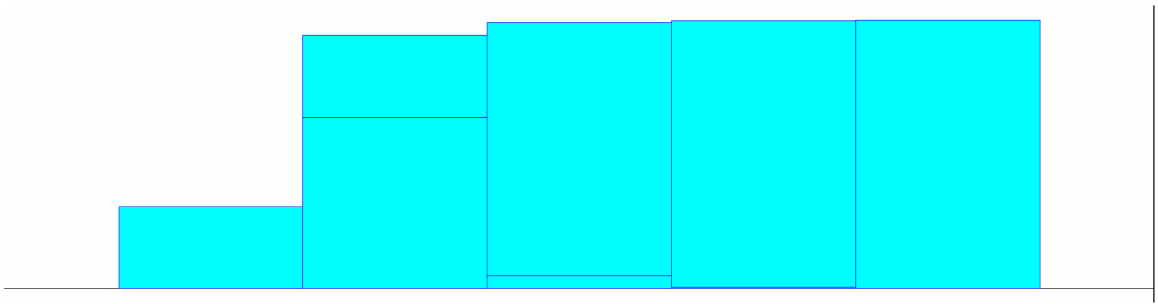


Figure 171. APG After Flight CS

Distribution Summary

Distribution: Empirical
Expression: DISC (0.000, 0.500, 0.305, 1.500, 0.944, 2.500, 0.991, 3.500, 0.998, 4.500, 0.998, 5.500)
DISC (0.000, 0, 0.305, 1, 0.944, 2, 0.991, 3, 0.998, 4, 1, 5)

Data Summary

Number of Data Points = 932
Min Data Value = 1
Max Data Value = 5
Sample Mean = 1.76
Sample Std Dev = 0.584

Histogram Summary

Histogram Range = 0.5 to 5.5
Number of Intervals = 5

Figure 172. APG After Flight CS

Electrical and Environmental (E&E) – Ground Abort – Duration.

The results after fitting all the distributions are presented in Figures 173 and 174. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is illustrated in Figures 175 and 176. The expression that was used in Arena for the duration of ground abort E&E failures is shown in Figure 176.

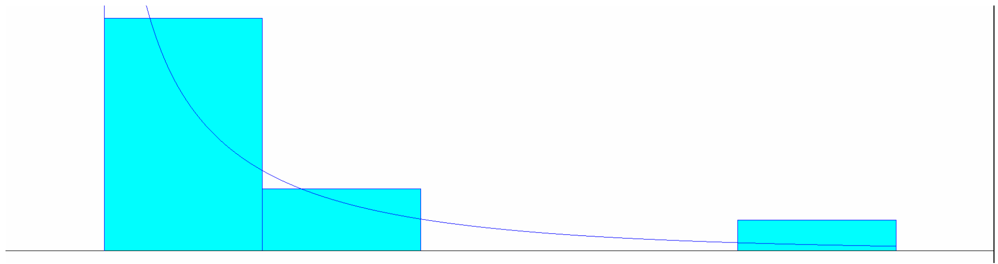


Figure 173. EandE Ground Abort Duration

Distribution Summary
Distribution: Weibull
Expression: 29 + WEIB(91.2, 0.679)
Square Error: 0.013564
Chi Square Test
Number of intervals = 2
Degrees of freedom = -1
Test Statistic = 0.427
Corresponding p-value < 0.005
Kolmogorov-Smirnov Test
Test Statistic = 0.191
Corresponding p-value > 0.15
Data Summary
Number of Data Points = 21
Min Data Value = 30
Max Data Value = 600
Sample Mean = 146
Sample Std Dev = 162
Histogram Summary
Histogram Range = 29 to 600
Number of Intervals = 5

Figure 174. EandE Ground Abort Duration

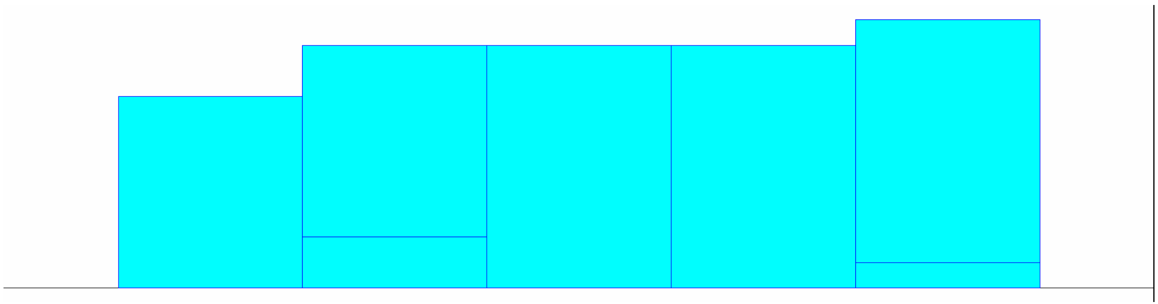


Figure 175. EandE Ground Abort Duration Empirical

Distribution Summary
Distribution: Empirical
Expression: CONT (0.000, 29.000, 0.714, 143.200, 0.905, 257.400, 0.905, 371.601, 0.905, 485.801, 0.905, 600.001, 1, 600.002)
Data Summary
Number of Data Points = 21
Min Data Value = 30
Max Data Value = 600
Sample Mean = 146
Sample Std Dev = 162
Histogram Summary
Histogram Range = 29 to 600
Number of Intervals = 5

Figure 176. EandE Ground Abort Duration Empirical

E&E – Ground Abort – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 177 and 178 and the expression that was used in Arena for the crew size of ground abort E&E failures is:

DISC (0.048, 1, 0.857, 2, 1, 3)

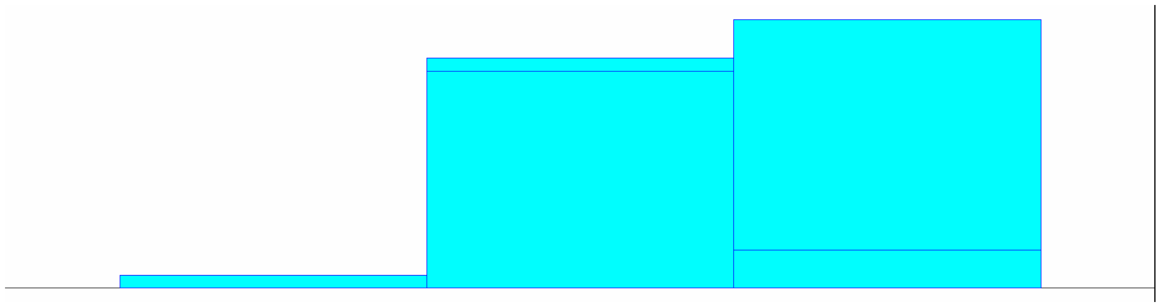


Figure 177. EandE Ground Abort CS

Distribution Summary
Distribution: Empirical
Expression: DISC (0.000, 0.500, 0.048, 1.500, 0.857, 2.500, 0.857, 3.500)
DISC (0.048, 1, 0.857, 2, 1, 3)

Data Summary

Number of Data Points = 21
Min Data Value = 1
Max Data Value = 3
Sample Mean = 2.1
Sample Std Dev = 0.436

Histogram Summary

Histogram Range = 0.5 to 3.5
Number of Intervals = 3

Figure 178. EandE Ground Abort CS

E&E – Air Abort – Duration.

The results after fitting all the distributions are presented in Figures 179 and 180. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is illustrated in Figures 181 and 182. The expression that was used in Arena for the duration of air abort E&E failures is shown in Figure 182.

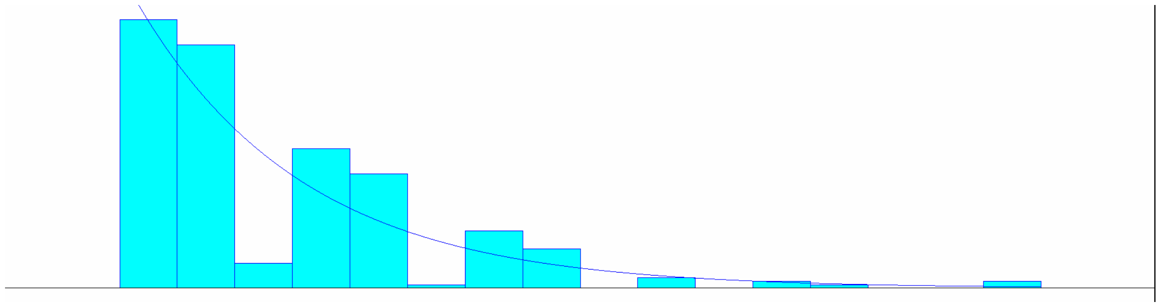


Figure 179. EandE Air Aborts Duration

Distribution Summary
Distribution: Exponential
Expression: EXPO(109)
Square Error: 0.026198
Chi Square Test
Number of intervals = 8
Degrees of freedom = 6
Test Statistic = 71.5
Corresponding p-value < 0.005
Kolmogorov-Smirnov Test
Test Statistic = 0.164
Corresponding p-value < 0.01

Data Summary

Number of Data Points = 257
Min Data Value = 0.99
Max Data Value = 600
Sample Mean = 109
Sample Std Dev = 99.6

Histogram Summary

Histogram Range = 0 to 600
Number of Intervals = 16

Figure 180. EandE Air Aborts Duration

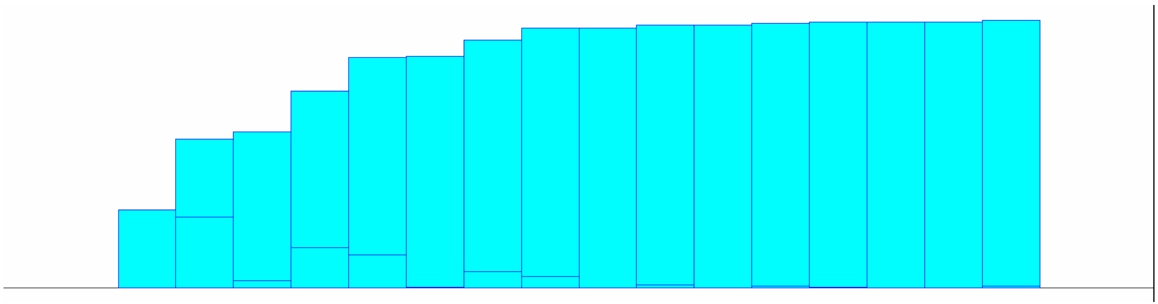


Figure 181. EandE Air Aborts Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 0.000, 0.292, 37.500, 0.556, 75.000, 0.584, 112.500, 0.735, 150.000, 0.860, 187.500, 0.864, 225.000, 0.926, 262.500, 0.969, 300.001, 0.969, 337.501, 0.981, 375.001, 0.981, 412.501, 0.988, 450.001, 0.992, 487.501, 0.992, 525.001, 0.992, 562.501, 0.992, 600.001, 1, 600.002)

Data Summary

Number of Data Points = 257
Min Data Value = 0.99
Max Data Value = 600
Sample Mean = 109
Sample Std Dev = 99.6

Histogram Summary

Histogram Range = 0 to 600
Number of Intervals = 16

Figure 182. EandE Air Aborts Duration Empirical

E&E – Air Abort – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 183 and 184 and the expression that was used in Arena for the crew size of air abort E&E failures is:

DISC (0.048, 1, 0.857, 2, 1, 3)

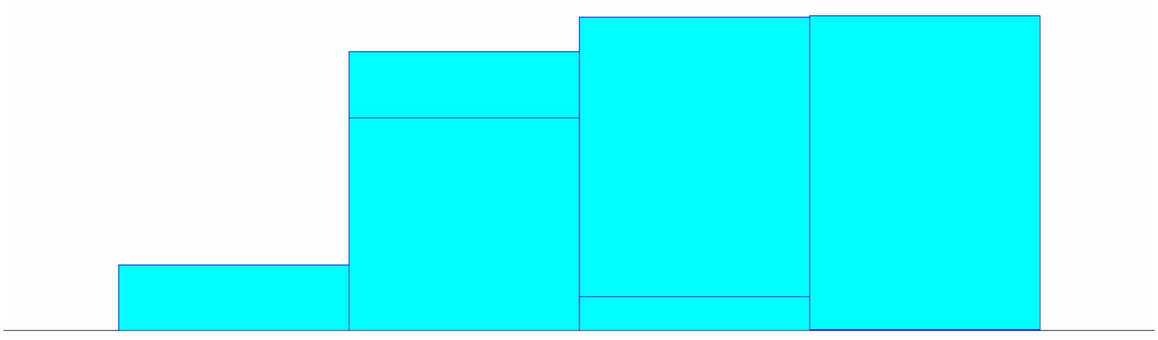


Figure 183. EandE Air Aborts CS

Distribution Summary
Distribution: Empirical
Expression: DISC (0.000, 0.500, 0.210, 1.500, 0.887, 2.500, 0.996, 3.500, 0.996, 4.500)
DISC (0.000, 0, 0.210, 1, 0.887, 2, 0.996, 3, 1, 4)

Data Summary

Number of Data Points = 257
Min Data Value = 1
Max Data Value = 4
Sample Mean = 1.91
Sample Std Dev = 0.572

Histogram Summary

Histogram Range = 0.5 to 4.5
Number of Intervals = 4

Figure 184. EandE Air Aborts CS

E&E – After Flight – Duration.

The results after fitting all the distributions are presented in Figures 185 and 186. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is

illustrated in Figures 187 and 188. The expression that was used in Arena for the duration of after flight E&E failures is shown in Figure 188.

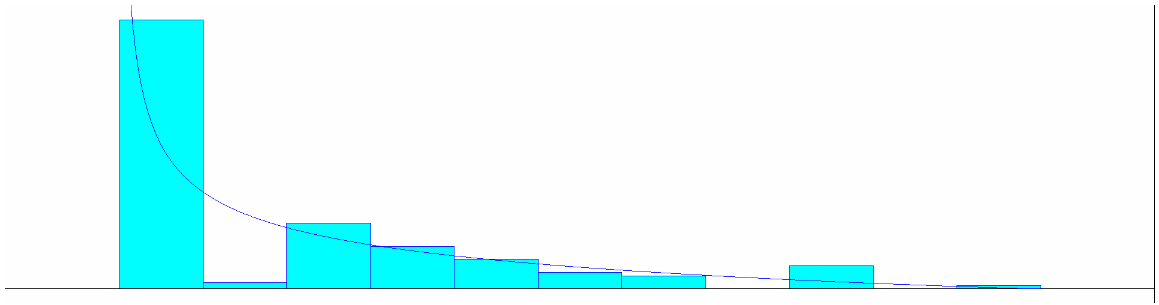


Figure 185. EandE After Flight Duration

Distribution Summary
Distribution: Beta
Expression: 9 + 591 * BETA(0.508, 2.1)
Square Error: 0.033015
Chi Square Test
  Number of intervals = 6
  Degrees of freedom = 3
  Test Statistic = 23.2
  Corresponding p-value < 0.005
Kolmogorov-Smirnov Test
  Test Statistic = 0.22
  Corresponding p-value < 0.01
Data Summary
Number of Data Points = 143
Min Data Value = 9.99
Max Data Value = 600
Sample Mean = 124
Sample Std Dev = 123

Histogram Summary

Histogram Range = 9 to 600
Number of Intervals = 11

Figure 186. EandE After Flight Duration

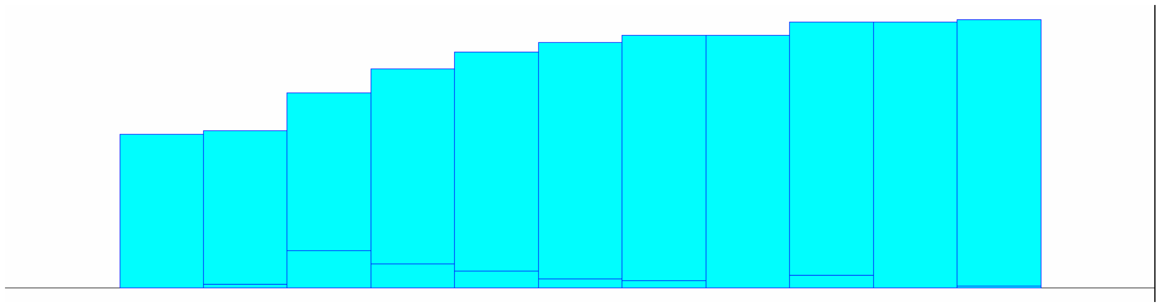


Figure 187. EandE After Flight Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 9.000, 0.573, 62.727, 0.587, 116.455, 0.727, 170.182, 0.818, 223.909, 0.881, 277.637, 0.916, 331.364, 0.944, 385.092, 0.944, 438.819, 0.993, 492.546, 0.993, 546.274, 0.993, 600.001, 1, 600.002)

Data Summary

Number of Data Points = 143
Min Data Value = 9.99
Max Data Value = 600
Sample Mean = 124
Sample Std Dev = 123

Histogram Summary

Histogram Range = 9 to 600
Number of Intervals = 11

Figure 188. EandE After Flight Duration Empirical

E&E – After Flight – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 189 and 190 and the expression that was used in Arena for the crew size of after flight E&E failures is:

DISC (0.000, 0, 0.182, 1, 0.846, 2, 0.979, 3, 1, 4)

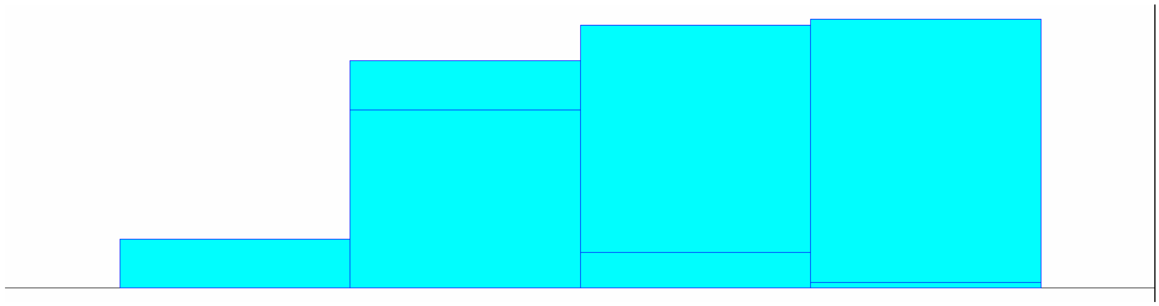


Figure 189. EandE After Flight CS

Distribution Summary Distribution: Empirical Expression: DISC (0.000, 0.500, 0.182, 1.500, 0.846, 2.500, 0.979, 3.500, 0.979, 4.500) DISC (0.000, 0, 0.182, 1, 0.846, 2, 0.979, 3, 1, 4) Data Summary Number of Data Points = 143 Min Data Value = 1 Max Data Value = 4 Sample Mean = 1.99 Sample Std Dev = 0.634 Histogram Summary Histogram Range = 0.5 to 4.5 Number of Intervals = 4

Figure 190. EandE After Flight CS

Avionics – Ground Abort – Duration.

The results after fitting all the distributions are presented in Figures 191 and 192. The corresponding p-values of both the K-S and the chi-square indicate that there is no evidence to reject the hypothesis that there is a good fit. Shifted beta theoretical

distribution was used for the Avionics ground abort failures duration (as shown in Figure 192).

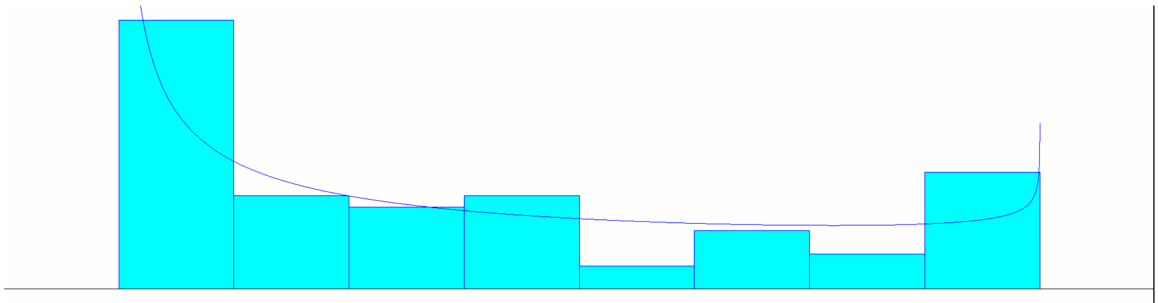


Figure 191. Avionics Ground Abort Duration

Distribution Summary	
Distribution:	Beta
Expression:	4 + 596 * BETA(0.514, 0.86)
Square Error:	0.009110
Chi Square Test	
Number of intervals	= 5
Degrees of freedom	= 2
Test Statistic	= 1.44
Corresponding p-value	= 0.491
Kolmogorov-Smirnov Test	
Test Statistic	= 0.151
Corresponding p-value	= 0.0922
Data Summary	
Number of Data Points	= 66
Min Data Value	= 4.99
Max Data Value	= 600
Sample Mean	= 227
Sample Std Dev	= 187
Histogram Summary	
Histogram Range	= 4 to 600
Number of Intervals	= 8

Figure 192. Avionics Ground Abort Duration

Avionics – Ground abort – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 193 and 194 and the expression that was used in Arena for the crew size of ground abort Avionics failures is:

DISC (0.000, 0, 0.015, 1, 0.621, 2, 0.939, 3, 1, 4)

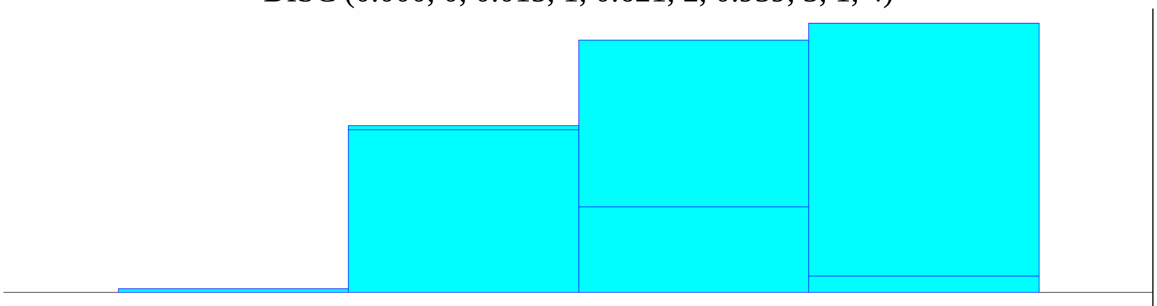


Figure 193. Avionics Ground Abort CS

Distribution Summary

Distribution: Empirical
Expression: DISC (0.000, 0.500, 0.015, 1.500, 0.621, 2.500, 0.939, 3.500, 0.939, 4.500)
DISC (0.000, 0, 0.015, 1, 0.621, 2, 0.939, 3, 1, 4)

Data Summary

Number of Data Points = 66
Min Data Value = 1
Max Data Value = 4
Sample Mean = 2.42
Sample Std Dev = 0.634

Histogram Summary

Histogram Range = 0.5 to 4.5
Number of Intervals = 4

Figure 194. Avionics Ground Abort CS

Avionics – Air Aborts – Duration and Crew Size.

There were no air aborts for Avionics failures. This information was incorporated in the model as zero failure rate for Avionics PWC during flight.

Avionics - After Flight – Duration.

The results after fitting all the distributions are presented in Figures 195 and 196. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is illustrated in Figures 197 and 198. The expression that was used in Arena for the duration of after flight Avionics failures is shown in Figure 198.

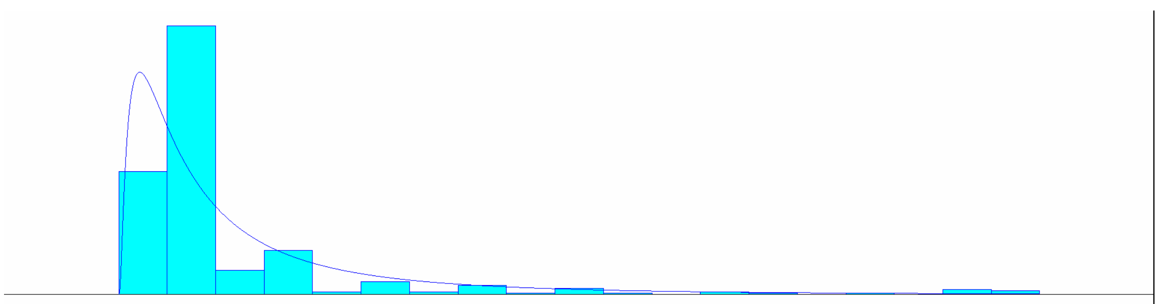


Figure 195. Avionics After Flight Duration

Distribution Summary
Distribution: Lognormal
Expression: 4 + LOGN(91.2, 146)
Square Error: 0.104057
Chi Square Test
Number of intervals = 9
Degrees of freedom = 6
Test Statistic = 193
Corresponding p-value < 0.005
Kolmogorov-Smirnov Test
Test Statistic = 0.283
Corresponding p-value < 0.01
Data Summary
Number of Data Points = 395
Min Data Value = 4.99
Max Data Value = 600
Sample Mean = 81.1
Sample Std Dev = 90.3

Histogram Summary

Histogram Range = 4 to 600
Number of Intervals = 19

Figure 196. Avionics After Flight Duration

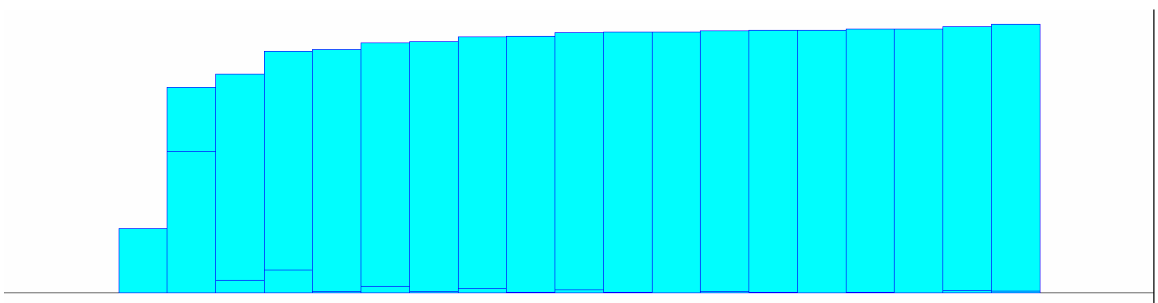


Figure 197. Avionics After Flight Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 4.000, 0.241, 35.368, 0.767, 66.737, 0.815, 98.105, 0.901, 129.474, 0.906, 160.842, 0.932, 192.211, 0.937, 223.579, 0.954, 254.948, 0.957, 286.316, 0.970, 317.685, 0.972, 349.053, 0.972, 380.422, 0.977, 411.790, 0.980, 443.159, 0.980, 474.527, 0.982, 505.896, 0.982, 537.264, 0.992, 568.633, 0.992, 600.001, 1, 600.002)

Data Summary

Number of Data Points = 395
Min Data Value = 4.99
Max Data Value = 600
Sample Mean = 81.1
Sample Std Dev = 90.3

Histogram Summary

Histogram Range = 4 to 600
Number of Intervals = 19

Figure 198. Avionics After Flight Duration Empirical

Avionics – After Flight – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 199 and 200 and the expression that was used in Arena for the crew size of after flight Avionics failures is:

DISC (.000, 0, 0.061, 1, 0.866, 2, 0.982, 3, 0.995, 4, 1, 5)

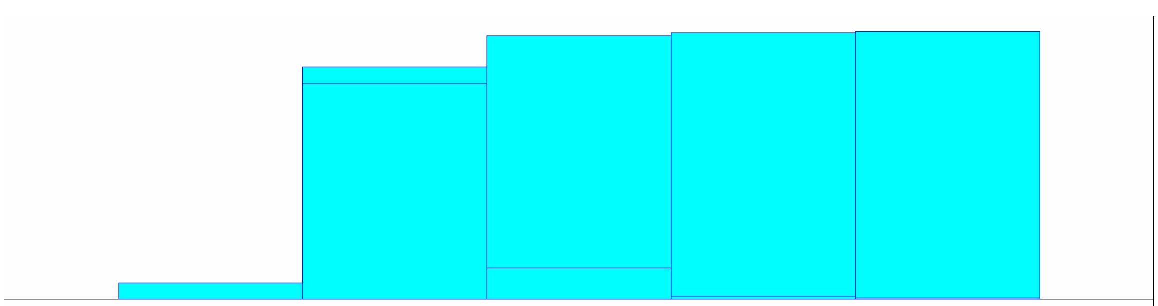


Figure 199. Avionics After Flight CS

Distribution Summary

Distribution: Empirical
Expression: DISC (0.000, 0.500, 0.061, 1.500, 0.866, 2.500, 0.982, 3.500, 0.995, 4.500, 0.995, 5.500)
DISC (0.000, 0, 0.061, 1, 0.866, 2, 0.982, 3, 0.995, 4, 1, 5)

Data Summary

Number of Data Points = 395
Min Data Value = 1
Max Data Value = 5
Sample Mean = 2.1
Sample Std Dev = 0.515

Histogram Summary

Histogram Range = 0.5 to 5.5
Number of Intervals = 5

Figure 200. Avionics After Flight CS

Engine – Ground Aborts – Duration.

The results after fitting all the distributions are presented in Figures 201 and 202. There are only eleven data points and there is no evidence that the lognormal distribution which has the “best fit” can be rejected in the good-fit hypothesis. The p-value is greater than 0.15 in the K-S test. The expression that was used in Arena for the duration of ground aborts Engine failures is:

LOGN(203, 771)

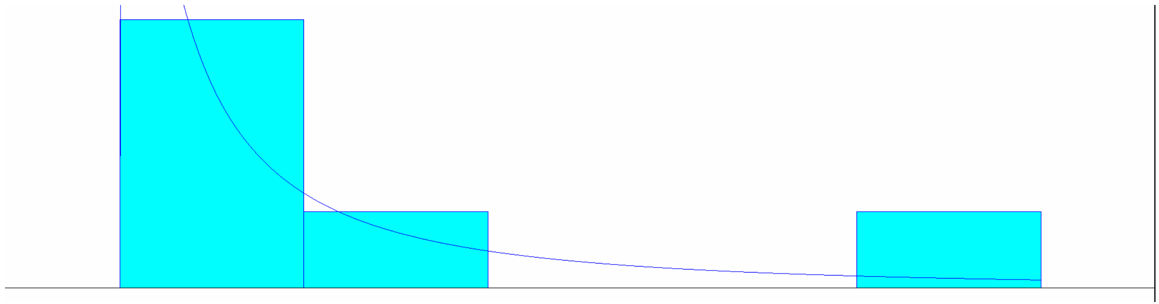


Figure 201. Engine Ground Aborts Duration

Distribution Summary

Distribution: Lognormal
Expression: LOGN(203, 771)
Square Error: 0.032237
Kolmogorov-Smirnov Test
Test Statistic = 0.193
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 11
Min Data Value = 0.99
Max Data Value = 480
Sample Mean = 132
Sample Std Dev = 176

Histogram Summary
Histogram Range = 0 to 480
Number of Intervals = 5

Figure 202. Engine Ground Aborts Duration

Engine – Ground Abort – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 203 and 204 and the expression that was used in Arena for the crew size of ground abort Engine failures is:

DISC (0.000, 1, 0.545, 2, 0.636, 3, 0.909, 4, 1, 5)

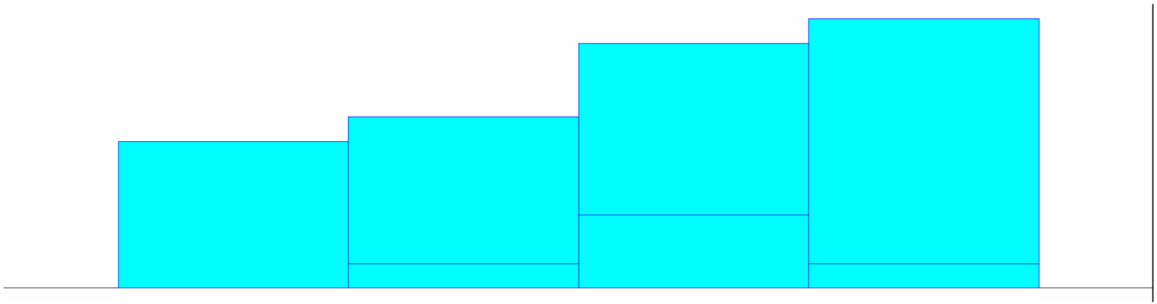


Figure 203. Engine Ground Aborts CS

Distribution Summary Distribution: Empirical Expression: DISC (0.000, 1.500, 0.545, 2.500, 0.636, 3.500,0.909, 4.500, 0.909, 5.500) DISC (0.000, 1, 0.545, 2, 0.636, 3, 0.909, 4, 1, 5) Data Summary Number of Data Points = 11 Min Data Value = 2 Max Data Value = 5 Sample Mean = 2.91 Sample Std Dev = 1.14 Histogram Summary Histogram Range = 1.5 to 5.5 Number of Intervals = 4

Figure 204. Engine Ground Aborts CS

Engine – Air Aborts – Duration.

The results after fitting all the distributions are presented in Figures 205 and 206. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is

illustrated in Figures 207 and 208. The expression that was used in Arena for the duration of air aborts Engine failures is shown in Figure 208.

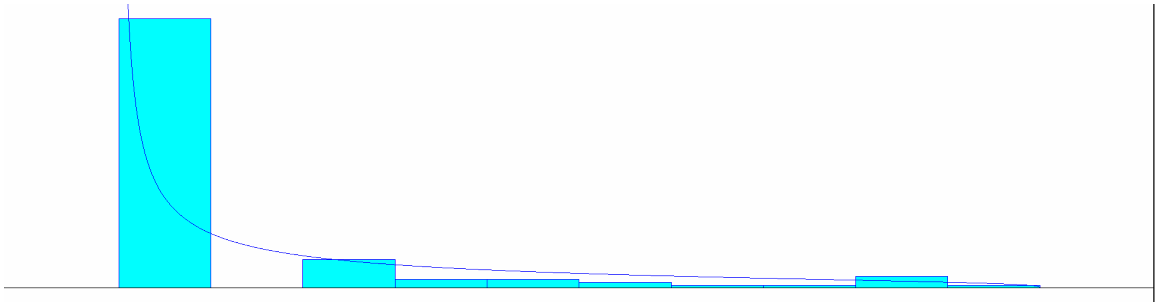


Figure 205. Engine Air Aborts Duration

Distribution Summary

Distribution: Beta
Expression: 14 + 526 * BETA(0.302, 1.31)
Square Error: 0.023368

Chi Square Test
Number of intervals = 5
Degrees of freedom = 2
Test Statistic = 20.4
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.232
Corresponding p-value < 0.01

Data Summary
Number of Data Points = 119
Min Data Value = 15
Max Data Value = 540
Sample Mean = 79.9
Sample Std Dev = 113

Histogram Summary

Histogram Range = 14 to 540
Number of Intervals = 10

Figure 206. Engine Air Aborts Duration

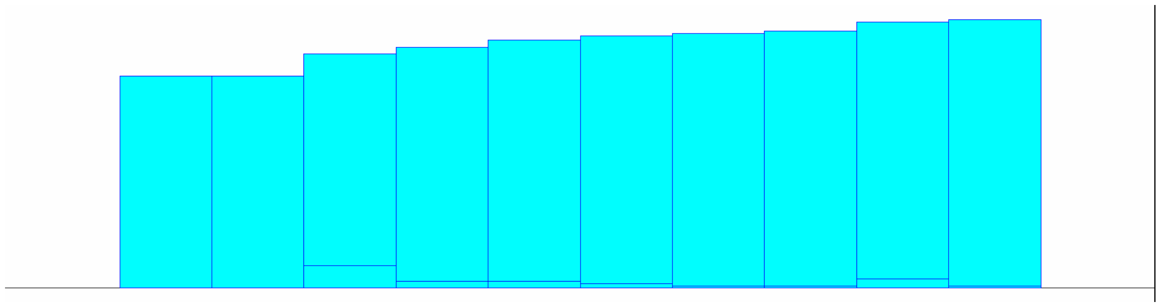


Figure 207. Engine Air Aborts Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 14.000, 0.790, 66.600, 0.790, 119.200, 0.874, 171.800, 0.899, 224.400, 0.924, 277.000, 0.941, 329.601, 0.950, 382.201, 0.958, 434.801, 0.992, 487.401, 0.992, 540.001, 1, 540.002)

Data Summary

Number of Data Points = 119
Min Data Value = 15
Max Data Value = 540
Sample Mean = 79.9
Sample Std Dev = 113

Histogram Summary

Histogram Range = 14 to 540
Number of Intervals = 10

Figure 208. Engine Air Aborts Duration Empirical

Engine – Air Aborts – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 209 and 210 and the expression that was used in Arena for the crew size of air aborts Engine failures is:

DISC (0, 0, 0.017, 1, 0.403, 2, 0.622, 3, 0.941, 4, 0.958, 5, 0.958, 6, 0.958, 7, 0.958, 8, 1, 9)

However, in accordance with the maintenance personnel data provided by Eielson AFB, the maximum available engine specialties are five (when days and swings shifts are working together). Failure data analysis showed that in almost 5 percent of the failures more than 5 persons were needed. It was assumed that the extra 4 persons were either "borrowed" from another squadron or another specialty as helping personnel. In order for the model to run smoothly and not block entities movement (when more than 5 engine persons are needed for a failure and the maximum available are only 5) the expression that was used in Arena for the crew size of air aborts Engine failures was edited to:

DISC (0, 0, 0.017, 1, 0.403, 2, 0.622, 3, 0.941, 4, 1, 5)

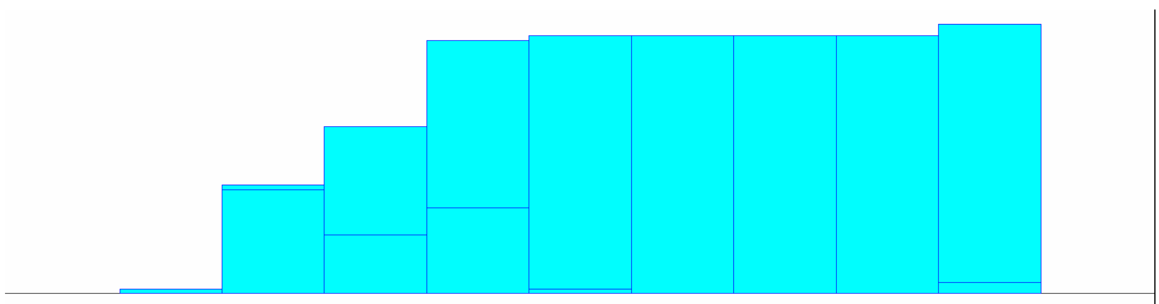


Figure 209. Engine Air Aborts CS

Distribution Summary

Distribution: Empirical
Expression: DISC (0.000, 0.500, 0.017, 1.500, 0.403, 2.500, 0.622, 3.500, 0.941, 4.500, 0.958, 5.500, 0.958, 6.500, 0.958, 7.500, 0.958, 8.500, 0.958, 9.500)
DISC (0.000, 0, 0.017, 1, 0.403, 2, 0.622, 3, 0.941, 4, 0.958, 5, 0.958, 6, 0.958, 7, 0.958, 8, 0.958, 9)

Data Summary
Number of Data Points = 119
Min Data Value = 1
Max Data Value = 9
Sample Mean = 3.18
Sample Std Dev = 1.53

Histogram Summary

Histogram Range = 0.5 to 9.5
Number of Intervals = 9

Figure 210. Engine Air Aborts CS

Engine – After Flight – Duration.

The results after fitting all the distributions are presented in Figures 211 and 212. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is illustrated in Figures 213 and 214. The expression that was used in Arena for the duration of after flight Engine failures is shown in Figure 214.

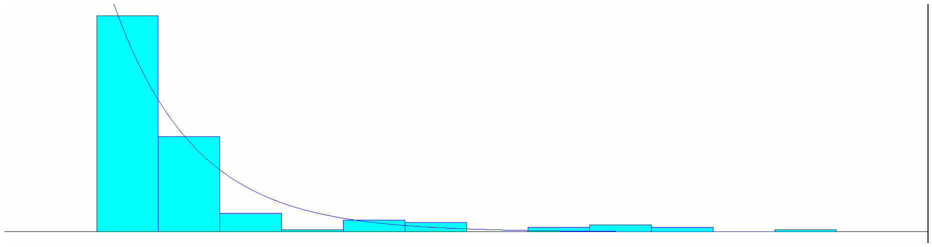


Figure 211. Engine After Flight Duration

Distribution Summary
Distribution: Exponential
Expression: 4 + EXPO(65.7)
Square Error: 0.010286
Chi Square Test
Number of intervals = 4
Degrees of freedom = 2
Test Statistic = 10.8
Corresponding p-value < 0.005
Kolmogorov-Smirnov Test
Test Statistic = 0.201
Corresponding p-value < 0.01

Data Summary
Number of Data Points = 160
Min Data Value = 4.99
Max Data Value = 600
Sample Mean = 69.7
Sample Std Dev = 107

Histogram Summary
Histogram Range = 4 to 600
Number of Intervals = 12

Figure 212. Engine After Flight Duration

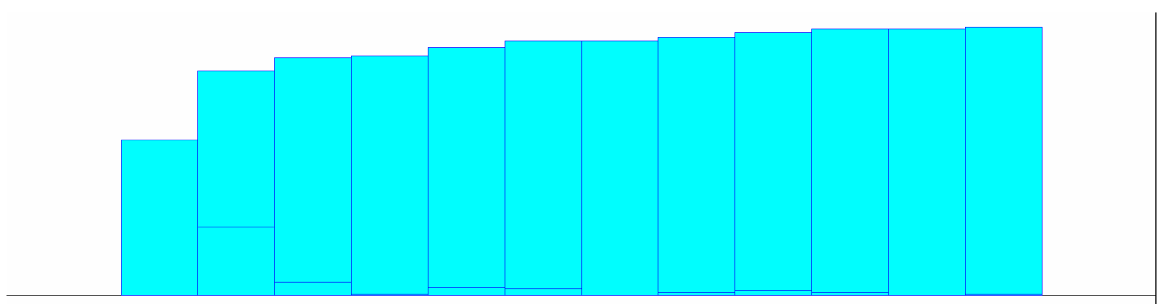


Figure 213. Engine After Flight Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 4.000, 0.581, 53.667, 0.838, 103.334, 0.888, 153.000, 0.894, 202.667, 0.925, 252.334, 0.950, 302.000, 0.950, 351.667, 0.963, 401.334, 0.981, 451.001, 0.994, 500.667, 0.994, 550.334, 0.994, 600.001)

Data Summary

Number of Data Points = 160
Min Data Value = 4.99
Max Data Value = 600
Sample Mean = 69.7
Sample Std Dev = 107

Histogram Summary

Histogram Range = 4 to 600
Number of Intervals = 12

Figure 214. Engine After Flight Duration Empirical

Engine – After Flight – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 215 and 216 and the expression that was used in Arena for the crew size of after flight Engine failures is:

DISC (0, 0, 0.050, 1, 0.431, 2, 0.506, 3, 0.956, 4, 1, 5)

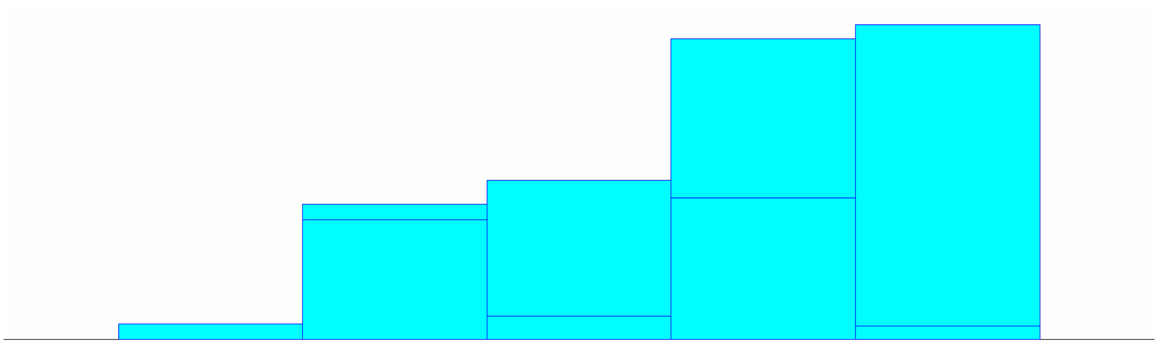


Figure 215. Engine After Flight CS

Distribution Summary

Distribution: Empirical
Expression: DISC (0.000, 0.500, 0.050, 1.500, 0.431, 2.500, 0.506, 3.500, 0.956, 4.500, 0.956, 5.500)
DISC (0, 0, 0.050, 1, 0.431, 2, 0.506, 3, 0.956, 4, 1, 5)

Data Summary
Number of Data Points = 160
Min Data Value = 1
Max Data Value = 5
Sample Mean = 3.06
Sample Std Dev = 1.1

Histogram Summary
Histogram Range = 0.5 to 5.5
Number of Intervals = 5

Figure 216. Engine After Flight CS

Weapons – Ground Abort – Duration.

The results after fitting all the distributions are presented in Figures 217 and 218. There are only nine data points and there is no evidence that the shifted Weibull distribution which has the "best fit" can be rejected in the good-fit hypothesis. The p-value is greater than 0.15 in the K-S test. The expression that was used in Arena for the duration of ground aborts Engine failures is:

30 + WEIB(0.587, 0.191)

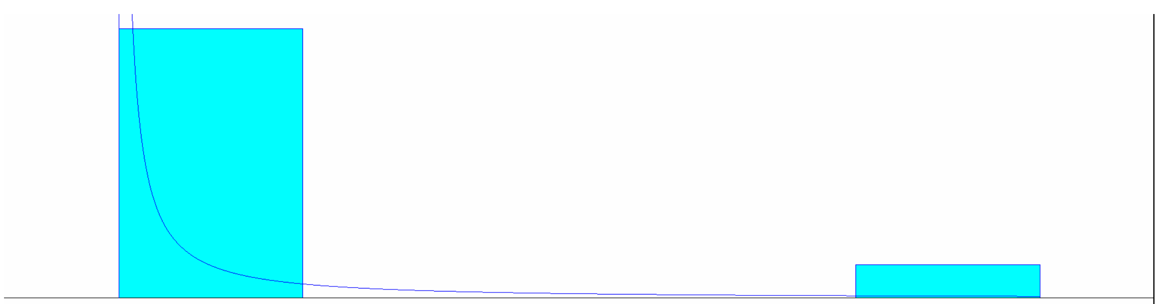


Figure 217. Weapons Ground Aborts Duration

Distribution Summary

Distribution: Weibull
Expression: 30 + WEIB(0.587, 0.191)
Square Error: 0.012098

Kolmogorov-Smirnov Test
Test Statistic = 0.256
Corresponding p-value > 0.15

Data Summary
Number of Data Points = 9
Min Data Value = 30
Max Data Value = 210
Sample Mean = 56.7
Sample Std Dev = 58.9

Histogram Summary
Histogram Range = 30 to 210
Number of Intervals = 5

Figure 218. Weapons Ground Aborts Duration

Weapons – Ground Abort – Crew Size.

All the nine weapons failures that were encountered in 1-year failure data were worked by three technicians. For the purpose of the model, the deterministic value of 3 weapon specialists was used for ground abort failures.

Weapons – Air Aborts – Duration.

The results after fitting all the distributions are presented in Figures 219 and 220. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is illustrated in Figures 221 and 222. The expression that was used in Arena for the duration of air aborts Weapons failures is shown in Figure 222.

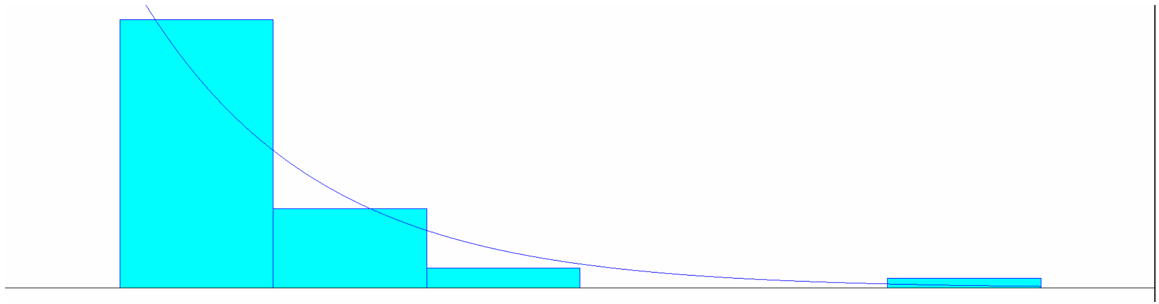


Figure 219. Weapons Air Aborts Duration

Distribution Summary
Distribution: Exponential
Expression: 5 + EXPO(33.6)
Square Error: 0.022871
Chi Square Test
Number of intervals = 3
Degrees of freedom = 1
Test Statistic = 5.36
Corresponding p-value = 0.0218
Kolmogorov-Smirnov Test
Test Statistic = 0.262
Corresponding p-value < 0.01

Data Summary
Number of Data Points = 38
Min Data Value = 5
Max Data Value = 180
Sample Mean = 38.5
Sample Std Dev = 31.3

Histogram Summary
Histogram Range = 5 to 180
Number of Intervals = 6

Figure 220. Weapons Air Aborts Duration

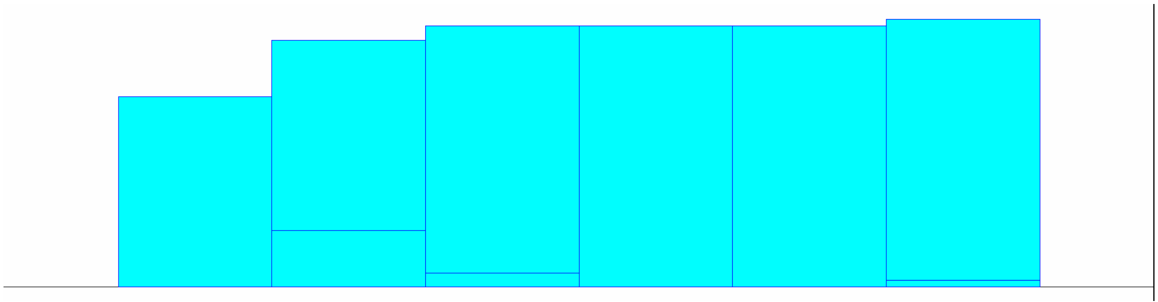


Figure 221. Weapons Air Aborts Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 4.999, 0.711, 34.166, 0.921, 63.333, 0.974, 92.500, 0.974, 121.667, 0.974, 150.834, 0.974, 180.001, 1, 180.002)

Data Summary
Number of Data Points = 38
Min Data Value = 5
Max Data Value = 180
Sample Mean = 38.5
Sample Std Dev = 31.3

Histogram Summary
Histogram Range = 5 to 180
Number of Intervals = 6

Figure 222. Weapons Air Aborts Duration Empirical

Weapons – Air Aborts – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 223 and 224 and the expression that was used in Arena for the crew size of air aborts Weapons failures is:

DISC (0.000, 0, 0.079, 1, 0.132, 2, 0.974, 3, 1, 4)

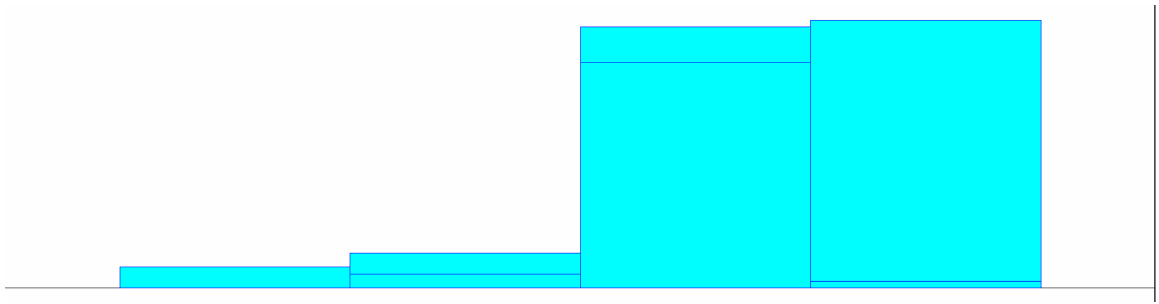


Figure 223. Weapons Air Aborts CS

Distribution Summary Distribution: Empirical Expression: CONT or DISC (0.000, 0.500, 0.079, 1.500, 0.132, 2.500, 0.974, 3.500, 0.974, 4.500) DISC (0.000, 0, 0.079, 1, 0.132, 2, 0.974, 3, 1, 4) Data Summary Number of Data Points = 38 Min Data Value = 1 Max Data Value = 4 Sample Mean = 2.82 Sample Std Dev = 0.609 Histogram Summary Histogram Range = 0.5 to 4.5 Number of Intervals = 4

Figure 224. Weapons Air Aborts CS

Weapons – After Flight – Duration.

The results after fitting all the distributions are presented in Figures 225 and 226. The corresponding p-values of both the K-S and the chi-square test are very small, so we can reject the good fit hypothesis. Empirical distribution might be used instead; it is illustrated in Figures 227 and 228. The expression that was used in Arena for the duration of after flight Weapons failures is shown in Figure 228.

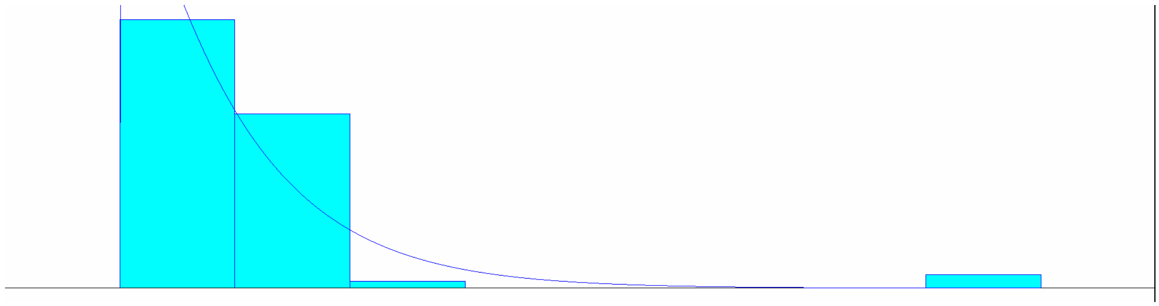


Figure 225. Weapons After Flight Duration

Distribution Summary

Distribution: Gamma
Expression: 9 + GAMM(36.8, 1.11)
Square Error: 0.028971

Chi Square Test
Number of intervals = 3
Degrees of freedom = 0
Test Statistic = 14.7
Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
Test Statistic = 0.204
Corresponding p-value < 0.01

Data Summary
Number of Data Points = 69
Min Data Value = 9.99
Max Data Value = 360
Sample Mean = 49.8
Sample Std Dev = 57.9

Histogram Summary
Histogram Range = 9 to 360
Number of Intervals = 8

Figure 226. Weapons After Flight Duration

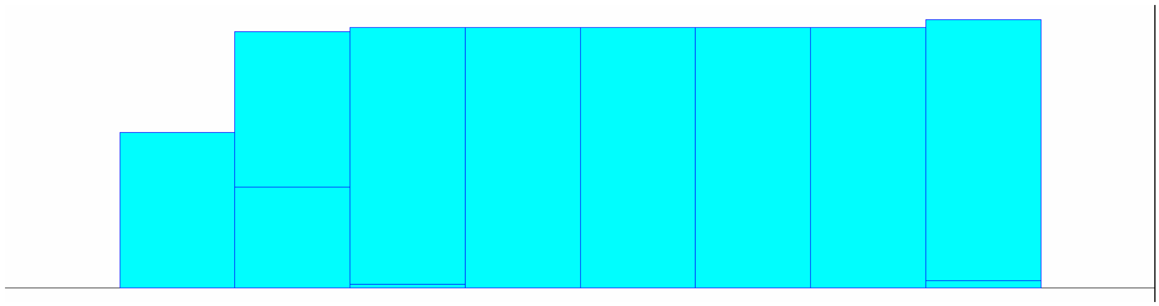


Figure 227. Weapons After Flight Duration Empirical

Distribution Summary

Distribution: Empirical
Expression: CONT (0.000, 9.000, 0.580, 52.875, 0.957, 96.750, 0.971, 140.625, 0.971, 184.500, 0.971, 228.376, 0.971, 272.251, 0.971, 316.126, 0.971, 360.001, 1, 360.002)

Data Summary
Number of Data Points = 69
Min Data Value = 9.99
Max Data Value = 360
Sample Mean = 49.8
Sample Std Dev = 57.9

Histogram Summary
Histogram Range = 9 to 360
Number of Intervals = 8

Figure 228. Weapons After Flight Duration Empirical

Weapons – After Flight – Crew Size.

Because of the discrete type of data (only one, two, three or more technicians can work) the DISCRETE function was used for empirical distribution fitting. The results are illustrated in Figures 229 and 230 and the expression that was used in Arena for the crew size of after flight Weapons failures is:

DISC (0.000, 1, 0.072, 2, 1, 3)

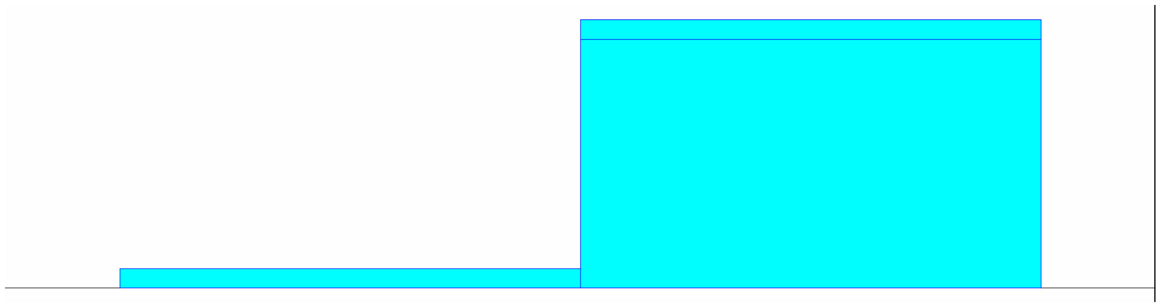


Figure 229. Weapons After Flight CS

Distribution Summary Distribution: Empirical Expression: DISC (0.000, 1.500, 0.072, 2.500, 0.072, 3.500) DISC (0.000, 1, 0.072, 2, 1, 3) Data Summary Number of Data Points = 69 Min Data Value = 2 Max Data Value = 3 Sample Mean = 2.93 Sample Std Dev = 0.261 Histogram Summary Histogram Range = 1.5 to 3.5 Number of Intervals = 2

Figure 230. Weapons After Flight CS

XV. Appendix "J". Vba Code

```
Public OptionToCheck As Integer

Private Sub CommandButton1_Click()

End Sub

Private Sub cmdCancel_Click()
    Unload Me
    End

End Sub

Private Sub cmdOK_Click()

    Dim oSIMAN As Arena.SIMAN
    Dim nOption As Long
    Dim nTakeoff1Index As Long
    Dim nTakeoff2Index As Long
    Dim nTakeoff3Index As Long
    Dim nTakeoff4Index As Long
    Dim nHrsBetwWaves As Long
    ' Dim swings_after, mids_prior, working_goal, duration_days As Long

    Set oSIMAN = ThisDocument.Model.SIMAN


    If OptionButton1.value = True Then
    OptionToCheck = 1

    ElseIf OptionButton4.value = True Then
    OptionToCheck = 2

    ElseIf OptionButton2.value = True Then
    OptionToCheck = 3

    ElseIf OptionButton5.value = True Then
    OptionToCheck = 4

    End If
    'MsgBox " Option to Check = " & OptionToCheck

    nOption = oSIMAN.SymbolNumber("varOption")
```

```
oSIMAN.VariableArrayValue(nOption) = OptionToCheck

nTakeoff1Index = oSIMAN.SymbolNumber("varTakeoff1")
oSIMAN.VariableArrayValue(nTakeoff1Index) = Takeoff1

nTakeoff2Index = oSIMAN.SymbolNumber("varTakeoff2")
oSIMAN.VariableArrayValue(nTakeoff2Index) = Takeoff2

nHrsBetwWaves = oSIMAN.SymbolNumber("varHrsBetwWaves")
oSIMAN.VariableArrayValue(nHrsBetwWaves) = HrsBetweenWaves

nJanSorties = oSIMAN.SymbolNumber("varJanSorties")
oSIMAN.VariableArrayValue(nJanSorties) = JanSorties

nFebSorties = oSIMAN.SymbolNumber("varFebSorties")
oSIMAN.VariableArrayValue(nFebSorties) = FebSorties

nMarSorties = oSIMAN.SymbolNumber("varMarSorties")
oSIMAN.VariableArrayValue(nMarSorties) = MarSorties

nAprSorties = oSIMAN.SymbolNumber("varAprSorties")
oSIMAN.VariableArrayValue(nAprSorties) = AprSorties

nMaySorties = oSIMAN.SymbolNumber("varMaySorties")
oSIMAN.VariableArrayValue(nMaySorties) = MaySorties

nJunSorties = oSIMAN.SymbolNumber("varJunSorties")
oSIMAN.VariableArrayValue(nJunSorties) = JunSorties

nJulSorties = oSIMAN.SymbolNumber("varJulSorties")
oSIMAN.VariableArrayValue(nJulSorties) = JulSorties

nAugSorties = oSIMAN.SymbolNumber("varAugSorties")
oSIMAN.VariableArrayValue(nAugSorties) = AugSorties

nSepSorties = oSIMAN.SymbolNumber("varSepSorties")
oSIMAN.VariableArrayValue(nSepSorties) = SepSorties

nOctSorties = oSIMAN.SymbolNumber("varOctSorties")
oSIMAN.VariableArrayValue(nOctSorties) = OctSorties

nNovSorties = oSIMAN.SymbolNumber("varNovSorties")
oSIMAN.VariableArrayValue(nNovSorties) = NovSorties

nDecSorties = oSIMAN.SymbolNumber("varDecSorties")
```

```
    oSIMAN.VariableArrayValue(nDecSorties) = DecSorties

    nSurge = oSIMAN.SymbolNumber("varPercentSurge")
    oSIMAN.VariableArrayValue(nSurge) = PercentSurge

    nworkinggoal = oSIMAN.SymbolNumber("varworking_goal")
    oSIMAN.VariableArrayValue(nworkinggoal) = working_goal

    ndaysprior = oSIMAN.SymbolNumber("vardays_prior")
    oSIMAN.VariableArrayValue(ndaysprior) = days_prior

    nmidsprior = oSIMAN.SymbolNumber("varmids_prior")
    oSIMAN.VariableArrayValue(nmidsprior) = mids_prior

    nswingsafter = oSIMAN.SymbolNumber("varswings_after")
    oSIMAN.VariableArrayValue(nswingsafter) = swings_after

    napgdays = oSIMAN.SymbolNumber("varapg_days")
    oSIMAN.VariableArrayValue(napgdays) = Int(apg_days * (1 + PercentPersonnel /
100))

    napgmids = oSIMAN.SymbolNumber("varapg_mids")
    oSIMAN.VariableArrayValue(napgmids) = Int(apg_mids * (1 + PercentPersonnel /
100))

    napgswings = oSIMAN.SymbolNumber("varapg_swings")
    oSIMAN.VariableArrayValue(napgswings) = Int(apg_swings * (1 + PercentPersonnel
/ 100))

    navionicsdays = oSIMAN.SymbolNumber("varavionics_days")
    oSIMAN.VariableArrayValue(navionicsdays) = Int(avionics_days * (1 +
PercentPersonnel / 100))

    navionicsmids = oSIMAN.SymbolNumber("varavionics_mids")
    oSIMAN.VariableArrayValue(navionicsmids) = Int(avionics_mids * (1 +
PercentPersonnel / 100))

    navionicsswings = oSIMAN.SymbolNumber("varavionics_swings")
    oSIMAN.VariableArrayValue(navionicsswings) = Int(avionics_swings * (1 +
PercentPersonnel / 100))

    neandedays = oSIMAN.SymbolNumber("vareande_days")
    oSIMAN.VariableArrayValue(neandedays) = Int(eande_days * (1 + PercentPersonnel
/ 100))
```

```
    neandemids = oSIMAN.SymbolNumber("vareande_mids")
    oSIMAN.VariableArrayValue(neandemids) = Int(eande_mids * (1 + PercentPersonnel
/ 100))

    neandeswings = oSIMAN.SymbolNumber("vareande_swings")
    oSIMAN.VariableArrayValue(neandeswings) = Int(eande_swings * (1 +
PercentPersonnel / 100))

    nenginedays = oSIMAN.SymbolNumber("varengine_days")
    oSIMAN.VariableArrayValue(nenginedays) = Int(engine_days * (1 +
PercentPersonnel / 100))

    nenginemids = oSIMAN.SymbolNumber("varengine_mids")
    oSIMAN.VariableArrayValue(nenginemids) = Int(engine_mids * (1 +
PercentPersonnel / 100))

    nengineswings = oSIMAN.SymbolNumber("varengine_swings")
    oSIMAN.VariableArrayValue(nengineswings) = Int(engine_swings * (1 +
PercentPersonnel / 100))

    nweaponsdays = oSIMAN.SymbolNumber("varweapons_days")
    oSIMAN.VariableArrayValue(nweaponsdays) = Int(weapons_days * (1 +
PercentPersonnel / 100))

    nweaponsmids = oSIMAN.SymbolNumber("varweapons_mids")
    oSIMAN.VariableArrayValue(nweaponsmids) = Int(weapons_mids * (1 +
PercentPersonnel / 100))

    nweaponsswings = oSIMAN.SymbolNumber("varweapons_swings")
    oSIMAN.VariableArrayValue(nweaponsswings) = Int(weapons_swings * (1 +
PercentPersonnel / 100))

    duration_mids = Int(mids_prior) - Int(days_prior) ' from mids report until days show
up
    duration_midsdays = Int(days_prior) + Int(working_goal) - Int(mids_prior) ' until mids
leave
    duration_days = Int(swings_after) + Int(mids_prior) - Int(working_goal) ' until swings
show up
    duration_daysswings = Int(working_goal) - Int(days_prior) - Int(swings_after) ' until
days leave
    duration_swings = Int(days_prior) + Int(swings_after) ' working_goal -
duration_daysswings

    ndurationmids = oSIMAN.SymbolNumber("varduration_mids")
    oSIMAN.VariableArrayValue(ndurationmids) = duration_mids
```

```
    ndurationmidsdays = oSIMAN.SymbolNumber("varduration_midsdays")
    oSIMAN.VariableArrayValue(ndurationmidsdays) = duration_midsdays

    ndurationdays = oSIMAN.SymbolNumber("varduration_days")
    oSIMAN.VariableArrayValue(ndurationdays) = duration_days

    ndurationdaysswings = oSIMAN.SymbolNumber("varduration_daysswings")
    oSIMAN.VariableArrayValue(ndurationdaysswings) = duration_daysswings

    ndurationswings = oSIMAN.SymbolNumber("varduration_swings")
    oSIMAN.VariableArrayValue(ndurationswings) = duration_swings

    nUnbalanced = oSIMAN.SymbolNumber("varunbalanced")
    oSIMAN.VariableArrayValue(nUnbalanced) = UnbalancedPercent

    SelectOption.Hide


   Exit Sub

End Sub
```

```
' Global variables
Dim oSIMAN As Arena.SIMAN, nMCRates As Long
Dim nNextRow As Long, nColumnA As Long, nColumnB As Long, nPreviousRow As
Long
Dim m As Model
Dim s As SIMAN

' Global Excel variables
Dim oExcelApp As Excel.Application, oWorkbook As Excel.Workbook, _
   oWorksheet As Excel.Worksheet
Public Function smsQtyOfWorkingDays(pvarStartDate As Variant, pvarEndDate As
Variant) As Integer
   On Error GoTo smsQtyOfWorkingDays_Err
   Dim lngStartDate As Long, lngEndDate As Long

   lngStartDate = CLng(CVDate(pvarStartDate))
   lngEndDate = CLng(CVDate(pvarEndDate))
   If lngStartDate <= lngEndDate Then
      smsQtyOfWorkingDays = DateDiff("w", lngStartDate, lngEndDate) * 5 +
smsQtyOfWorkingDaysBetween2WeekDays(Weekday(lngStartDate),
Weekday(lngEndDate))
   Else
      lngStartDate = CLng(CVDate(pvarEndDate))
      lngEndDate = CLng(CVDate(pvarStartDate))
      smsQtyOfWorkingDays = -(DateDiff("w", lngStartDate, lngEndDate) * 5 +
smsQtyOfWorkingDaysBetween2WeekDays(Weekday(lngStartDate),
Weekday(lngEndDate)))
   End If

smsQtyOfWorkingDays_Done:
   Exit Function
smsQtyOfWorkingDays_Err:
   Resume smsQtyOfWorkingDays_Done
End Function

Function smsQtyOfWorkingDaysBetween2WeekDays(intFirstWeekDay As Integer,
intSecondWeekDay As Integer)
   On Error GoTo smsQtyOfWorkingDaysBetween2WeekDays_Err

   smsQtyOfWorkingDaysBetween2WeekDays = 0
   Dim intForIdx As Integer, intCycle2 As Integer, intCnt As Integer

   intCnt = 0
```

```
   If intFirstWeekDay <> intSecondWeekDay Then
      If intFirstWeekDay < intSecondWeekDay Then
         intCycle2 = intSecondWeekDay
      Else
         intCycle2 = intSecondWeekDay + 7
      End If

      For intForIdx = intFirstWeekDay To intCycle2 - 1
          Select Case intForIdx Mod 7
       Case 1, 7:
       Case 2, 3, 4, 5, 6: intCnt = intCnt + 1
       Case Else
          End Select
      Next intForIdx
   End If
   smsQtyOfWorkingDaysBetween2WeekDays = intCnt

smsQtyOfWorkingDaysBetween2WeekDays_Done:
   Exit Function
smsQtyOfWorkingDaysBetween2WeekDays_Err:
   Resume smsQtyOfWorkingDaysBetween2WeekDays_Done
End Function



Public Function FirstOfMonth(Optional dteDate As Date) As Date

  ' This function calculates the first day of a month, given a date.
  ' If no date is passed in, the function uses the current date.

  If CLng(dteDate) = 0 Then
    dteDate = Date
  End If

  ' Find the first day of this month.
  FirstOfMonth = DateSerial(Year(dteDate), Month(dteDate), 1)
End Function

Public Function LastOfMonth(Optional dteDate As Date) As Date

  ' This function calculates the last day of a month, given a date.
  ' If no date is passed in, the function uses the current date.

  If CLng(dteDate) = 0 Then
    dteDate = Date
```

```
    End If

    ' Find the first day of the next month, then subtract one day.
    LastOfMonth = DateSerial(Year(dteDate), Month(dteDate) + 1, 1) - 1
End Function



Public Function IsWorkday(Optional dteDate As Date) As Boolean
    ' This function determines whether a date
    ' falls on a weekday.

    ' If no date passed in, use today's date.
    If CLng(dteDate) = 0 Then
        dteDate = Date
    End If

    ' Determine where in week the date falls.
    Select Case Weekday(dteDate)
        Case vbMonday To vbFriday
            IsWorkday = True
        Case Else
            IsWorkday = False
    End Select
End Function


Public Function FlightsPerMonth() As Integer

Set k = ThisDocument.Model
Set p = k.SIMAN

CurMonth = p.CalendarMonth(p.RunCurrentTime)

     dSurge = oSIMAN.SymbolNumber("varPercentSurge")
     PercentSurge = oSIMAN.VariableArrayValue(dSurge)


Select Case CurMonth
Case 1 'Jan
     dJanSorties = oSIMAN.SymbolNumber("varJanSorties")
     FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dJanSorties) * (1 + PercentSurge
/ 100))
Case 2 'Feb
     dFebSorties = oSIMAN.SymbolNumber("varFebSorties")
```

```
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dFebSorties) * (1 +
PercentSurge / 100))
Case 3 'Mar
   dMarSorties = oSIMAN.SymbolNumber("varMarSorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dMarSorties) * (1 +
PercentSurge / 100))
Case 4 'Apr
   dAprSorties = oSIMAN.SymbolNumber("varAprSorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dAprSorties) * (1 +
PercentSurge / 100))
Case 5 'May
   dMaySorties = oSIMAN.SymbolNumber("varMaySorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dMaySorties) * (1 +
PercentSurge / 100))
Case 6 'Jun
   dJunSorties = oSIMAN.SymbolNumber("varJunSorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dJunSorties) * (1 + PercentSurge
/ 100))
Case 7 'Jul
   dJulSorties = oSIMAN.SymbolNumber("varJulSorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dJulSorties) * (1 + PercentSurge
/ 100))
Case 8 'Aug
   dAugSorties = oSIMAN.SymbolNumber("varAugSorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dAugSorties) * (1 +
PercentSurge / 100))
Case 9 'Sep
   dSepSorties = oSIMAN.SymbolNumber("varSepSorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dSepSorties) * (1 +
PercentSurge / 100))
Case 10 'Oct
   dOctSorties = oSIMAN.SymbolNumber("varOctSorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dOctSorties) * (1 +
PercentSurge / 100))
Case 11 'Nov
   dNovSorties = oSIMAN.SymbolNumber("varNovSorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dNovSorties) * (1 +
PercentSurge / 100))
Case 12 'Dec
   dDecSorties = oSIMAN.SymbolNumber("varDecSorties")
   FlightsPerMonth = Int(oSIMAN.VariableArrayValue(dDecSorties) * (1 +
PercentSurge / 100))
End Select

End Function
```

```
Private Sub ModelLogic_RunBeginSimulation()
   ' Set the global SIMAN variable
   Set oSIMAN = ThisDocument.Model.SIMAN

   ' Start Excel and create a new spreadsheet
   Set oExcelApp = CreateObject("Excel.Application")
   oExcelApp.Visible = True
   oExcelApp.SheetsInNewWorkbook = 1
   Set oWorkbook = oExcelApp.Workbooks.Add

   Set oWorksheet = oWorkbook.ActiveSheet
   With oWorksheet
      .Name = "Statistics"
      .Rows(1).Select
      oExcelApp.Selection.Font.Bold = True
      oExcelApp.Selection.Font.color = RGB(255, 0, 0)
   End With
End Sub

Private Sub ModelLogic_RunBeginReplication()
   Dim nReplicationNum As Long, i As Integer

   ' Set variables for the columns to which data is to be written
   nReplicationNum = oSIMAN.RunCurrentReplication
   nColumnA = (12 * (nReplicationNum - 1)) + 1
   nColumnB = nColumnA + 1
   nColumnC = nColumnA + 2
   nColumnD = nColumnA + 3
   nColumnE = nColumnA + 4
   nColumnF = nColumnA + 5
   nColumnG = nColumnA + 6
   nColumnH = nColumnA + 7
   nColumnI = nColumnA + 8
   nColumnJ = nColumnA + 9
   nColumnK = nColumnA + 10

   ' Write header row for MCRates
   '  set nNextRow to 2 to start writing data in third row
   With oWorksheet
      .Activate
      .Cells(1, nColumnA).value = "Simulation Day"
      .Cells(1, nColumnB).value = "MCRate"
      .Cells(1, nColumnC).value = "Can Fly"
```

```
        .Cells(1, nColumnD).value = "Cum Hours Flown"
        .Cells(1, nColumnE).value = "Cum Sorties"
        .Cells(1, nColumnF).value = "Option"
        .Cells(1, nColumnG).value = "DailyDuration"
        .Cells(1, nColumnH).value = "MonthlySortiesGoal"
        .Cells(1, nColumnI).value = "CumMonthlySorties"
        .Cells(1, nColumnJ).value = "TodaySorties"
        .Cells(1, nColumnK).value = "APG_mids"
        For i = 0 To 10
            .Columns(nColumnA + i).Select
            oExcelApp.Selection.Columns.AutoFit
            ' oExcelApp.Selection.NumberFormat = "0.00"
        Next i
    End With
    nNextRow = 2
    nPreviousRow = 0
    CumMonthlySorties = 0
    SelectOption.Show
End Sub

Private Sub VBA_Block_1_Fire()
    ' Retrieve create time and current time from SIMAN object data
    Dim dCreateDay As String, dMCRate As Double, CanFly As Double, HrsFlown As
Double, SortiesPerDay As Integer, Option1 As Integer
    Dim DDailyDuration As Long
    Dim nReplicationNum As Long, i As Integer, CumMonthlySorties As Integer

    ' Set variables for the columns to which data is to be written
    nReplicationNum = oSIMAN.RunCurrentReplication
    nColumnA = (12 * (nReplicationNum - 1)) + 1
    nColumnB = nColumnA + 1
    nColumnC = nColumnA + 2
    nColumnD = nColumnA + 3
    nColumnE = nColumnA + 4
    nColumnF = nColumnA + 5
    nColumnG = nColumnA + 6
    nColumnH = nColumnA + 7
    nColumnI = nColumnA + 8
    nColumnJ = nColumnA + 9
    nColumnK = nColumnA + 10

    FPM = FlightsPerMonth()
```

```
    dCreateDay = oSIMAN.CalendarMonth(oSIMAN.RunCurrentTime) & "/" &
oSIMAN.CalendarDayOfMonth(oSIMAN.RunCurrentTime) & "/" &
oSIMAN.CalendarYear(oSIMAN.RunCurrentTime)
    dMCRate = oSIMAN.SymbolNumber("MCRate")
    dCanFly = oSIMAN.SymbolNumber("CanFly")
    HrsFlown = oSIMAN.SymbolNumber("HrsFlown")
    SortiesPerDay = oSIMAN.SymbolNumber("SortiesPerDay")
    SortiesPerOneDay = oSIMAN.SymbolNumber("SortiesThisDay")
    Option1 = oSIMAN.SymbolNumber("varOption")
    DDailyDuration = oSIMAN.SymbolNumber("DailyDuration")
    MCRate = oSIMAN.VariableArrayValue(dMCRate)
    CanFly = oSIMAN.VariableArrayValue(dCanFly)
    HrFl = oSIMAN.VariableArrayValue(HrsFlown)
    SPD = oSIMAN.VariableArrayValue(SortiesPerDay)
    SPOneD = oSIMAN.VariableArrayValue(SortiesPerOneDay)
    Opt = oSIMAN.VariableArrayValue(Option1)
    DDuration = oSIMAN.VariableArrayValue(DDailyDuration)
    CumMonthlySorties = CumMonthlySorties + SortiesPerDay

    apg = oSIMAN.SymbolNumber("varapg_mids")
    napg = oSIMAN.VariableArrayValue(apg)

     'dCreateTime = oSIMAN.EntityAttribute(oSIMAN.ActiveEntity, _
        nArrivalTimeAttrIndex)
    'dCurrentTime = oSIMAN.RunCurrentTime

    ' Write the values to the spreadsheet

    If nPreviousRow > 1 Then
      CumMonthlySorties = oWorksheet.Cells(nPreviousRow, nColumnI).value + SPOneD
    Else
    CumMonthlySorties = 0
    End If

    If oSIMAN.CalendarDayOfMonth(oSIMAN.RunCurrentTime) = 1 Then
        CumMonthlySorties = SPOneD
    End If

    With oWorksheet
        .Cells(nNextRow, nColumnA).value = dCreateDay
        .Cells(nNextRow, nColumnB).value = MCRate
        .Cells(nNextRow, nColumnC).value = CanFly
        .Cells(nNextRow, nColumnD).value = HrFl
        .Cells(nNextRow, nColumnE).value = SPD
        .Cells(nNextRow, nColumnF).value = Opt
```

```
        .Cells(nNextRow, nColumnG).value = DDuration
        .Cells(nNextRow, nColumnH).value = FPM
        .Cells(nNextRow, nColumnI).value = CumMonthlySorties
        .Cells(nNextRow, nColumnJ).value = SPOneD
        .Cells(nNextRow, nColumnK).value = napg
    End With

    ' Increment the row variable
    nPreviousRow = nNextRow
    nNextRow = nNextRow + 1
End Sub

Private Sub ModelLogic_RunEndReplication()
    ' Chart today's sales call data on a separate chart sheet
    'oWorkbook.Sheets("Statistics").Select
    'oWorksheet.Range(oWorksheet.Cells(3, nColumnC), oWorksheet.Cells(nNextRow,
nColumnC)).Select
    'oExcelApp.Charts.Add

    ' Format the chart
    'With oExcelApp.ActiveChart
    '    .ChartType = xlLineMarkers
    '    .SetSourceData Source:=oWorksheet.Range(oWorksheet.Cells(3, nColumnC),
oWorksheet.Cells(nNextRow, nColumnC)), PlotBy:=xlColumns
    '    .SeriesCollection(1).XValues = ""
    '    .Location Where:=xlLocationAsNewSheet, Name:="Day " &
oSIMAN.RunCurrentReplication & " Calls"
    '    .HasTitle = True              ' Title and Y axis
    '    .HasAxis(xlValue) = True
    '    .HasAxis(xlCategory) = False  ' No X axis or Legend
    '    .HasLegend = False
    '    .ChartTitle.Characters.Text = "Call Times"
    '    .Axes(xlValue).MaximumScale = 60
    '    .Axes(xlValue).HasTitle = True
    '    .Axes(xlValue).AxisTitle.Characters.Text = "minutes"
    'End With
End Sub

Private Sub ModelLogic_RunEndSimulation()
    ' Save the spreadsheet
    oExcelApp.DisplayAlerts = False           ' Don't prompt to overwrite
    oWorkbook.SaveAs ThisDocument.Model.Path & "ThesisModel.xls"
End Sub

Private Sub ModelLogic_DocumentOpen()
```

```
End Sub


Public Function ModelLogic_UserFunction(ByVal entityID As Long, ByVal functionID
As Long) As Double

Dim FlyingDays, ACperWave, WavesPerMonth, CurrentHour, NumberAircraft As
Integer

WaveBatchQueue = oSIMAN.SymbolNumber("NumberInWaveQueue")
WQ = oSIMAN.VariableArrayValue(WaveBatchQueue)

PercentUnbalance = oSIMAN.SymbolNumber("varunbalanced")
PU = oSIMAN.VariableArrayValue(PercentUnbalance)

'WeekFromLastDayOfMonth =
oSIMAN.SymbolNumber("varWeekFromLastDayOfMonth")
'lastweek = oSIMAN.VariableArrayValue(WeekFromLastDayOfMonth)


Set m = ThisDocument.Model
Set s = m.SIMAN

SDate = FirstOfMonth(s.RunCurrentTime)
EDate = LastOfMonth(s.RunCurrentTime) + 1
'lastweek =
' CurMonth = DatePart("m", s.RunCurrentTime)
CurrentHour = s.CalendarHour(s.RunCurrentTime)
NumberAircaft = 18
'FlyingDays = 20
FlyingDays = smsQtyOfWorkingDays(SDate, EDate)
' FlightsPerMonth = 400
FPM1 = FlightsPerMonth()
' FPM1 = 500

' MsgBox " Returns a value of " & FlyingDays & " " & SDate & " " & EDate & " " &
CurMonth & " " & FlightsPerMonth

Select Case functionID

Case 1 '3 waves M - F Balanced Approach
WavesPerMonth = 3 * FlyingDays
ACperWave = Round(FPM1 / WavesPerMonth)
```

```
If ACperWave > NumberAircaft Then
   ModelLogic_UserFunction = Round(3 / 4 * NumberAircaft)
'ElseIf CurrentHour > 20 And WQ < ACperWave Then
'    ModelLogic_UserFunction = WQ
Else
   ModelLogic_UserFunction = ACperWave
End If

Case 2 '3 waves M - R 1 wave F, assume 4 Fridays per month
WavesPerMonth = 3 * FlyingDays - 8
ACperWave = Round(FPM1 / WavesPerMonth)
If ACperWave > NumberAircaft Then
   ModelLogic_UserFunction = Round(3 / 4 * NumberAircaft)
'ElseIf CurrentHour > 20 And WQ < ACperWave Then
'    ModelLogic_UserFunction = WQ
Else
   ModelLogic_UserFunction = ACperWave
End If

Case 3 '3 waves M - F Un-Balanced Approach
WavesPerMonth = 3 * FlyingDays
ACperWave = Round(FPM1 / WavesPerMonth)

random_number = Rnd

If random_number > 0.5 Then
   multiplier = 1
Else
   multiplier = -1
End If

If ACperWave > NumberAircaft Then
   ModelLogic_UserFunction = Round(3 / 4 * NumberAircaft) * (1 + multiplier * PU /
100)
'ElseIf CurrentHour > 20 And WQ < ACperWave Then
 '   ModelLogic_UserFunction = WQ
Else
   ModelLogic_UserFunction = ACperWave * (1 + multiplier * PU / 100)
End If

Case 4 '12X10 3 weeks 10p10X8 one week per month

HotPitWeek = oSIMAN.SymbolNumber("varHotPitWeek")
HPW = oSIMAN.VariableArrayValue(HotPitWeek)
```

```
PWave = oSIMAN.SymbolNumber("CurrentWave")
PW = oSIMAN.VariableArrayValue(PWave)

If HotPitWeek = 0 Then '12X10
   Select Case PW
      Case 0
         ACperWave = 12
      Case 1
         ACperWave = 10
   End Select
Else '10p10X8
   Select Case PW
      Case 0
         ACperWave = 10
      Case 1
         ACperWave = 10 ' hot pit
      Case 2
         ACperWave = 8
   End Select
End If

ModelLogic_UserFunction = ACperWave

End Select

'MsgBox " UF() returns a value of " & ModelLogic_UserFunction

End Function
```

XVI. Appendix “K”. 1ST Investigative Question – Delphi Responses

1st Round Responses

These were the initial responses in answering the 1st investigative question during the 1st round of the Delphi study.

1. Although I have no experience with aircraft, I have had experience with an aging weapon system, the Minuteman II and III ICBMs. In my experience, the key to keeping an aging weapon system up and running is periodic maintenance. An aircraft, just like a missile system, has many mechanical components that require inspection, repair, and replacement as necessary. All too many times, our focus is on NMC maintenance at the expense of periodic requirements. This can, and often does, lead to a fatal perpetuation of NMC problems. Therefore, any scheduling philosophy should revolve around periodic maintenance requirements, in my mind, to prevent the failure of the little things which can lead to bigger failures. Also, there has to be a cooperative effort between Ops and Maintenance. I've heard it is similar to the missile world where there seems to be a constant battle of wills. All of us have to keep the big picture in mind, as we have learned (some of us already knew), to ensure that our real goal is met, which is to fight if necessary and win if it is necessary. These are just broad philosophical points to consider.
2. 1. Relying on Cann birds for parts. Seems some aircraft will be under utilized for sake of MC rate. MC Rate/Life tradeoff. 2. No-fly Fridays
3. The best maintenance philosophy we maintained at McGuire was NO CANN bird. CANNing parts is an excuse for Supply not to do its job. Canning requires the work to be done 3 times...once to remove the working part on the CANN bird,

once to install the part on the broken jet, and once to replace the part on the CANN bird. This translates to a complete waste of the maintainers' time. We also wanted the reservists to fly on Saturday and keep the jets down on Sunday for repair and strong start to the week...we were never able to get complete Reservist buy-in...so I can't say if this works or not. You can check GO81...this philosophy works.

4. The philosophy of flying 1 "large" wave on Fridays versus 2 "normal" waves. (For example: 14-turn-0 vs. 12-turn-12) The philosophy of flying 1 "normal" wave on Fridays versus 2 "normal" waves. (For example: 12-turn-0 vs. 12-turn-12) Extended versus condensed flying window. Combining day- and night-flying into the same flying window versus separating day- and night-flying into different flying windows. For certain systems, it seems that the more the aircraft flies the more reliable the system, to a point. However, for long-term HOF issues, the less an aircraft flies (lower flight hours) the longer the life of the aircraft.
5. Flying hour goals and the Sortie UTE rate drive the schedule outline. Building on this outline several strategies are used to fill in the details: 1. Sortie surges: used to increase UTE 2. Increased average sortie duration (ASD): used to increase hours 3. Fly heavy at the beginning of the fiscal year and let off later
6. Consistent flying operations are the first goal. Little use of a cann jet (C-5 lessons-earned during Iraqi Freedom offers a great example of the benefits of no cann jet).
7. One philosophy is to limit how much each individual aircraft flies--in other words, keep your UTE rate under a certain level.

8. Configuration management - minimizing the number of configurations an AMU or an AMXS flies in on a given day. # of front lines must be a function of aircraft availability, not Ops requests. Turn patterns can be adjusted to accommodate fewer front lines. At least 12 hours between last down and first go to allow reasonable fix rate, again, allowing more availability to meet the schedule.
9. Please be aware in answering these questions I did not make scheduling policies but merely implemented them. Philosophies 2 times pit-n-go + night go on Mon-Wed, light 3x turn (std 2+15 no ordnance or 2+30 for BDU-33s or 3+00 for live/heavy weight inert ordnance) on Thurs & Fri for mx to recover 3 fronts on Mon-Wed, 2xpit-n-go on Thurs, then one go Friday to recover (this schedule normally included surge weeks to catch up sorties/hours) Units also employed: Cancel flying for 1 to 2 days to reconfigure for deployments or exercises Flying windows across the wing were minimized more so than in the squadron (squadron was more concerned with range and turn times than flying window) I also saw squadrons that did one jet at a time in phase and others that did 2 jets at a time in phase Configuration changes are always hotly contested with mx lobbying for the fewest possible changes and ops
10. Sortie surge once per month vs. once per quarter 2. The "balanced approach" of spreading the schedule out equally throughout the week/month. 3. Examine the UTE rate...is it realistic if we want to improve the health of the fleet? 4. Can we adjust the ASD to maximize pilot training while perhaps reducing the number of sorties that are required? 5. "Pit and Go" daily vs. two to three time per week. 6. Shorten the flying window to maximize maintenance time (not always feasible at

all locations, i.e. airspace restrictions, host nation regulations, etc.)

11. As the maintenance officer for a squadron of 14 F/A-18F's, I found that it was absolutely imperative to set aside one day when we stopped flying for 4 hours in the middle of the day to conduct maintenance training. We chose Wednesdays from 1400-1800. This allowed 1 hour to finish things up before training began and 1 hour to get started up after training ended. The two hours of maintenance training were instrumental in keeping everyone in the department up to date with the latest information and maintain all 43 maintenance programs (such as hydraulic contamination, oil consumption, fuel surveillance, etc.) on track. With frequent turnover of personnel, it was important to not sacrifice training in order to meet flight hour objectives. Flights could be flown earlier in the day, later at night, or on a different day. Also, some squadron opted to fly 4 days a week and have numerous three day weekends. We opted not to go this route as all too often it results in 5 days of flying being compressed into 4 days with no time left for preventative maintenance. We demanded 2.5 hours between land time and takeoff time. Once again, we could have flown harder, but wanted the extra time for preventative maintenance as well as training.
12. Flying one wave on Fridays if operational requirements are met. Minimize the flying window. The more the aircraft is flown, the more reliable it is. Reconstitution down-time after deployment. Phase Time Distribution Interval.
13. I would compare the One Go Friday with the Minimum Fly Window (i.e. use shortest turn times as possible) but I suspect these will not provide much of a CV or CD (i.e. I see them as complementary and probably contribute to increased

aircraft reliability because of longer stretches of aircraft down-time where the crew can take their time and really inspect the jets). I think that where the big differences will be found are in units that fly to meet RAP only without regard to fleet health. This may be influenced by such things as restricted range times/space or unavailability of DACT units to team up with, etc. Of course these variables of interest will be unit mission dependant (i.e. A-G vs A-A).

14. Scheduling longer sorties to accomplish as many tasks as possible on one take-off/landing and making use of aerial refueling (A/R) as much as possible; Schedule more sorties at night when possible to allow more robust day shifts to recover and repair a/c flown the night before
15. The most common approach to improving the long term health of the fleet that I have seen is to stick religiously to the scheduled maintenance schedule. In other words, never sacrifice or delay scheduled maintenance actions to meet the flying hour program. Shortened flying windows (< 9 hours) and one-go Fridays are also good for the long term health of the fleet. However, this is a secondary benefit. The primary benefit to shortened flying windows and one-go Fridays is that it allows greater flexibility to managers in allocating their workforce to shifts throughout the maintenance day. A shortened flying window means that day shift can do the majority of daily generation actions on the planes to meet the daily schedule. You can put mostly 5-level and 3-level crew chiefs, as well as cut-trained 3-level specialists on this shift to generate and recover the aircraft. Swing shift becomes your most vital shift for actual maintenance actions and you can stack your shift with experienced crew chiefs and specialists to ensure broken

planes get fixed in time for the next days flying. By regulation, mids is only supposed to consist of a servicing crew - very little heavy maintenance can get done. A shortened flying window means shift schedules can be tailored to the type of maintenance that will take place. longer flying windows means two shifts are involved in generation and recovery. Turn-over is always cheated since planes are landing as swings is ariving to work - this hampers effective communication. One-go Fridays means as servicing can be done on days and heavy maintenance on swings. Since mids works Sunday night-Monday morning, a one-go Friday means no people have to have to work friday night-Saturday morning mids. This also means that weekend duty can be limited to only those personnel required to continue working breaks on aircraft needed to fly the next week's schedule. A two-go Friday pushes the start of heavy maintenance until later in the evening, forcing managers to have more people come in over the weekend to fix jets. Although both of the strategies above are used primarily to effect shift scheduling, they have an undeniable positive affect on the long term health of the fleet.

16. The jets that fly the most are the most reliable UTE rate vs. flying hour program -- adding hours without adding sorties can affect the fleet

XVII. Appendix "L". Box – Plots for 1ST Investigative Question's Results

What is a Box-Plot

The outlier box plot is a schematic that lets someone see the sample distribution and identify points with extreme values, the outliers. Box plots show selected quantiles of continuous distributions[23]. An example is shown below:

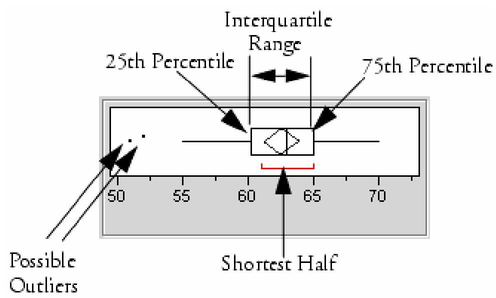


Figure 231. Box Plot

The ends of the box are the 25th and the 75th quantiles, also called the quartiles. The difference between the quartiles is the interquartile range. The line across the middle of the box identifies the median sample value and the means diamond indicates the sample mean and the 95% confidence interval. The lines extending from both ends, the whiskers, starts from the ends of the box and finish to the outer most data point that falls with the distances computed by:

upper quartile + 1.5 * (interquartile range)

upper quartile - 1.5 * (interquartile range)

The bracket along the edge of the box identifies the shortest half, which is the most dense 50% of the observations. Outliers are shown with points.

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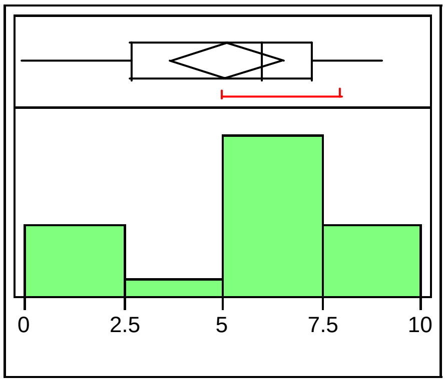
[23] It is assumed that the 0-10 scale that was used in ranking the initial results can be transformed in continuous form without changing the properties of the responses.

Box Plots

Below are the box plots for the responses concerning the 1st investigative question. The responses are presented sorted by the mean in descending order.

Q1AF



Quantiles

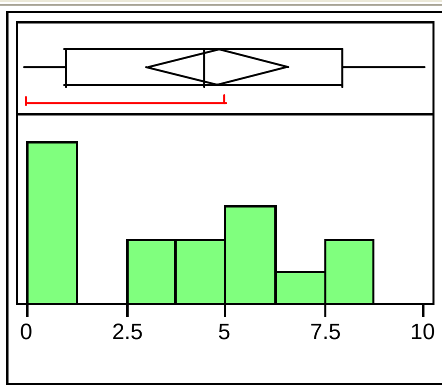
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		8.1000
75.0%	quartile	7.2500
50.0%	median	6.0000
25.0%	quartile	2.7500
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	5.1111111
Std Dev	2.8052239
Std Err Mean	0.6611976
upper 95% Mean	6.5061161
lower 95% Mean	3.7161061
N	18

Figure 232. Box Plot for at Least 12 hours between Last down and First go

Q1AH



Quantiles

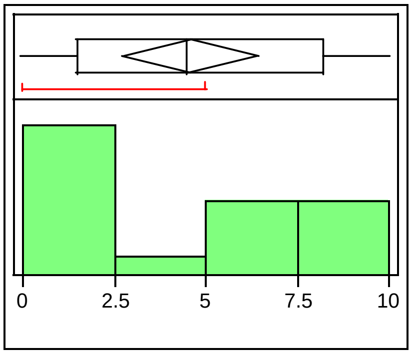
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	8.000
50.0%	median	4.500
25.0%	quartile	1.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	4.8333333
Std Dev	3.4852631
Std Err Mean	0.8214844
upper 95% Mean	6.5665139
lower 95% Mean	3.1001528
N	18

Figure 233. Box Plot for Ensuring Enough Downtime for Maintenance

Q1AG



Quantiles

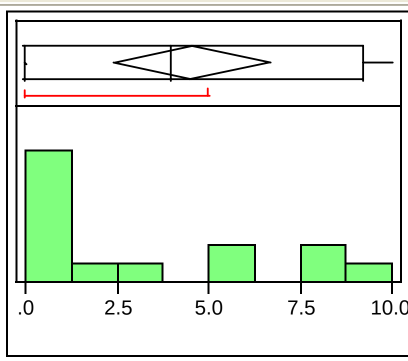
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	8.250
50.0%	median	4.500
25.0%	quartile	1.500
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	4.6111111
Std Dev	3.6644378
Std Err Mean	0.8637163
upper 95% Mean	6.4333932
lower 95% Mean	2.7888291
N	18

Figure 234. Box Plot for 30-days Limit in Keeping a Plane Down

Q1AA



Quantiles

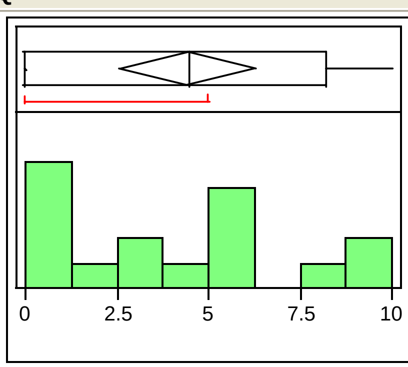
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	9.250
50.0%	median	4.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	4.5555556
Std Dev	4.2039508
Std Err Mean	0.9908807
upper 95% Mean	6.6461311
lower 95% Mean	2.46498
N	18

Figure 235. Box Plot for "Balanced" Approach of Spreading the Schedule out

Q1AD



Quantiles

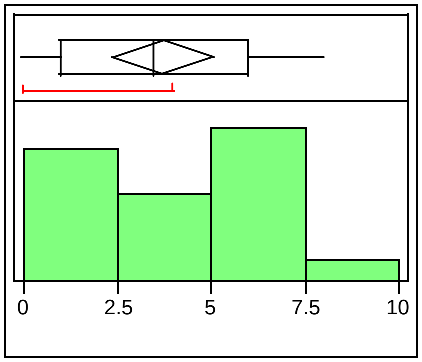
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	8.250
50.0%	median	4.500
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	4.4444444
Std Dev	3.681787
Std Err Mean	0.8678055
upper 95% Mean	6.275354
lower 95% Mean	2.6135348
N	18

Figure 236. Box Plot for 2.5 Hours between Land – Takeoff

Q1AM



Quantiles

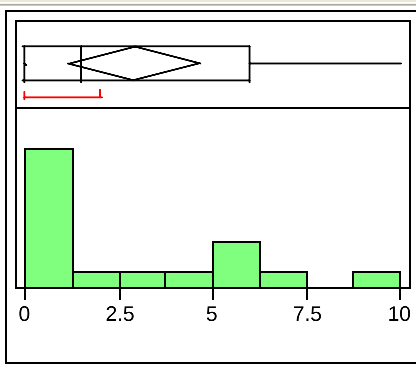
100.0%	maximum	8.0000
99.5%		8.0000
97.5%		8.0000
90.0%		7.1000
75.0%	quartile	6.0000
50.0%	median	3.5000
25.0%	quartile	1.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	3.7222222
Std Dev	2.6525361
Std Err Mean	0.6252088
upper 95% Mean	5.0412974
lower 95% Mean	2.4031471
N	18

Figure 237. Box Plot for Minimizing the Number of Configurations

Q1AK



Quantiles

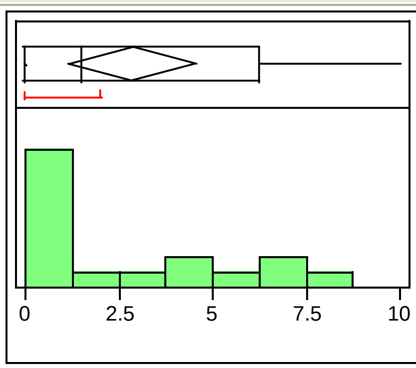
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	6.000
50.0%	median	1.500
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.9444444
Std Dev	3.4380607
Std Err Mean	0.8103587
upper 95% Mean	4.6541518
lower 95% Mean	1.2347371
N	18

Figure 238. Box Plot for Increasing Average Sortie Duration

Q1AL



Quantiles

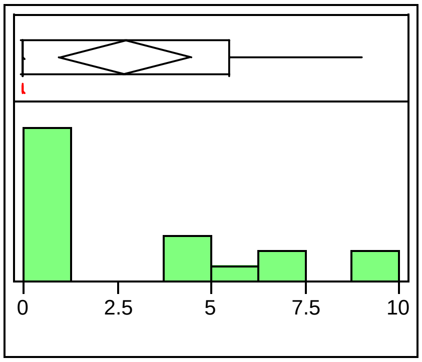
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		8.200
75.0%	quartile	6.250
50.0%	median	1.500
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.8888889
Std Dev	3.376195
Std Err Mean	0.7957768
upper 95% Mean	4.5678312
lower 95% Mean	1.2099466
N	18

Figure 239. Box Plot for Keeping UTE Rate under Certain Level

Q1AC



Quantiles

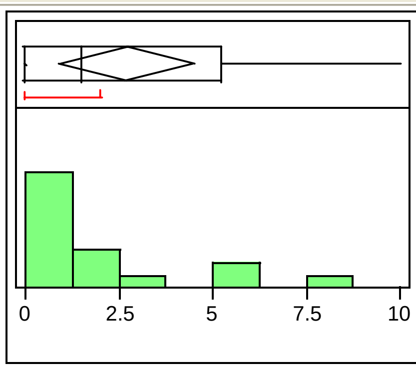
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		9.0000
75.0%	quartile	5.5000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.7222222
Std Dev	3.4266354
Std Err Mean	0.8076657
upper 95% Mean	4.4262479
lower 95% Mean	1.0181965
N	18

Figure 240. Box Plot for 1 "Normal" Wave on Fridays

Q1AS



Quantiles

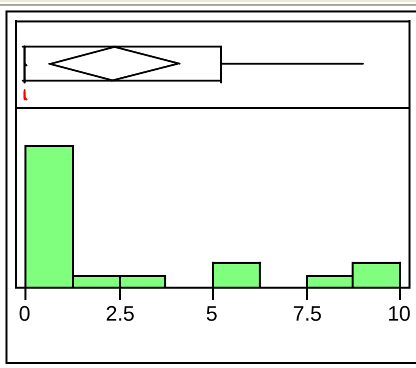
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	5.250
50.0%	median	1.500
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.7222222
Std Dev	3.5447651
Std Err Mean	0.8355091
upper 95% Mean	4.4849924
lower 95% Mean	0.959452
N	18

Figure 241. Box Plot for Aircraft is More Reliable if it Flies More

Q1AN



Quantiles

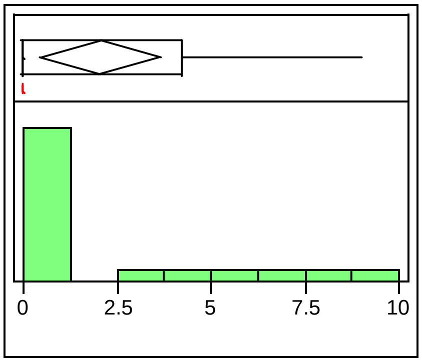
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		9.0000
75.0%	quartile	5.2500
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.3888889
Std Dev	3.4151718
Std Err Mean	0.8049637
upper 95% Mean	4.0872139
lower 95% Mean	0.6905639
N	18

Figure 242. Box Plot for no Cann Birds

Q1AJ



Quantiles

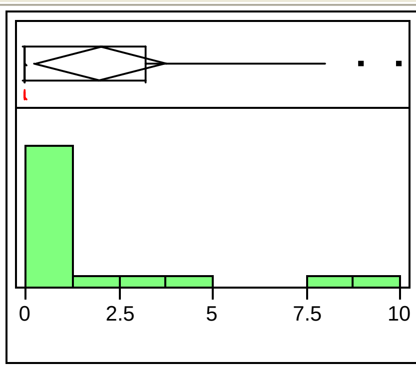
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		8.1000
75.0%	quartile	4.2500
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.0555556
Std Dev	3.1524448
Std Err Mean	0.7430384
upper 95% Mean	3.6232295
lower 95% Mean	0.4878816
N	18

Figure 243. Box Plot for Flying Heavy at the Beginning of Fiscal Year

Q1AE



Quantiles

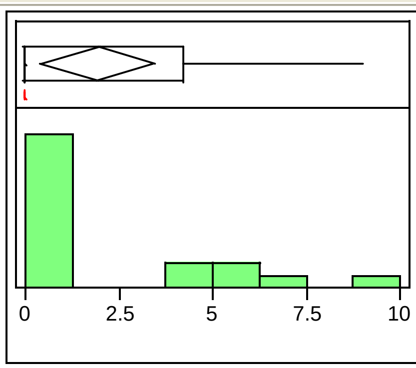
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	3.250
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2
Std Dev	3.4470789
Std Err Mean	0.8124843
upper 95% Mean	3.714192
lower 95% Mean	0.285808
N	18

Figure 244. Box Plot for Adjusted Turn Patterns for Fewer Front Lines

Q1AR



Quantiles

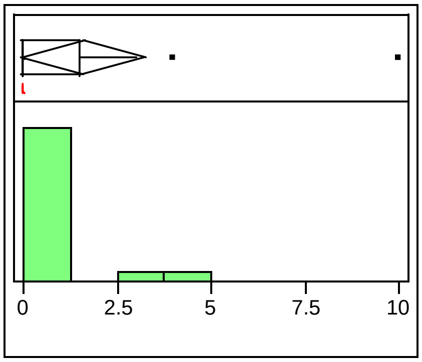
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		7.2000
75.0%	quartile	4.2500
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	1.9444444
Std Dev	3.019003
Std Err Mean	0.7115858
upper 95% Mean	3.4457593
lower 95% Mean	0.4431296
N	18

Figure 245. Box Plot for Sortie Surge Once per Month

Q1AO



Quantiles

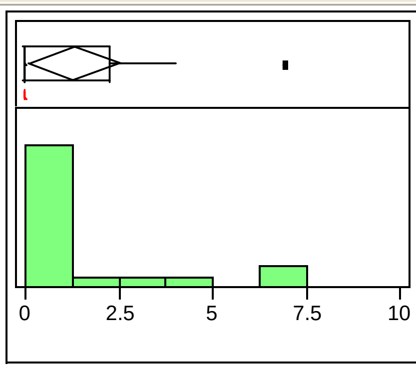
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	1.500
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	1.6111111
Std Dev	3.2564667
Std Err Mean	0.7675566
upper 95% Mean	3.2305139
lower 95% Mean	-0.008292
N	18

Figure 246. Box Plot for No-fly Fridays

Q1AP



Quantiles

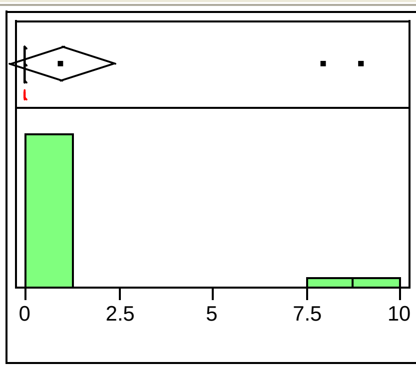
100.0%	maximum	7.0000
99.5%		7.0000
97.5%		7.0000
90.0%		7.0000
75.0%	quartile	2.2500
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	1.3333333
Std Dev	2.3763541
Std Err Mean	0.560112
upper 95% Mean	2.5150664
lower 95% Mean	0.1516002
N	18

Figure 247. Box Plot for Pit and Go Daily

Q1AB



Quantiles

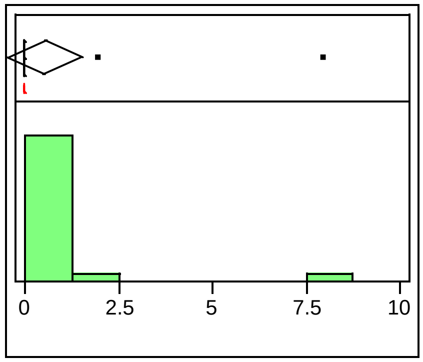
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		8.1000
75.0%	quartile	0.0000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	1
Std Dev	2.7439774
Std Err Mean	0.6467617
upper 95% Mean	2.3645478
lower 95% Mean	-0.364548
N	18

Figure 248. Box Plot for 1 “Large” Wave on Fridays

Q1AQ



Quantiles

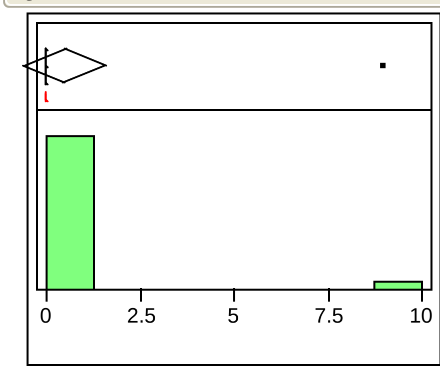
100.0%	maximum	8.0000
99.5%		8.0000
97.5%		8.0000
90.0%		2.6000
75.0%	quartile	0.0000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	0.5555556
Std Dev	1.9165601
Std Err Mean	0.4517375
upper 95% Mean	1.5086385
lower 95% Mean	-0.397527
N	18

Figure 249. Box Plot for Scheduling More Sorties at Night

Q1AI



Quantiles

100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		0.9000
75.0%	quartile	0.0000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	0.5
Std Dev	2.1213203
Std Err Mean	0.5
upper 95% Mean	1.5549078
lower 95% Mean	-0.554908
N	18

Figure 250. Box Plot for Extended Flying Window

XVIII. Appendix “M”. Content Analysis Results

Table 9. Content Analysis Results

Aircraft Maintenance Performance Factor	**Researcher(s)**								
“D”: Dependent, “I”: Independent	Davis & Walker (1992)	Jung (1991)	Gilliland (1990)	Diener & Hood (1980)	Allison (1999)	Beabout (2003)	Commenator (2001)	Oliver (2001)	Faas (2003)
Mission Capable Rate (MC Rate)	D	D	D	D	D	D		D	D
Scheduling Effectiveness Rate				D		D	D		D
Not Mission Capable Maintenance Rate (NMCM Rate)	I	I		D			D	I	D
Maintenance ManHours Per Flying Hour	I	I	D	D			D		
Maintenance Scheduling Effectiveness			D			D	D		
Repeat Discrepancy Rate			D	D			D		
Air Abort Rate	I	I			D		I		D
Ground Abort Rate				D			I		D
Aircraft Sortie Utilization Rate	I	I					I		D
Not Mission Capable Supply Rate (NMCS Rate)	I	I					I		D
Aircraft Hourly Utilization Rate	I						I		D
Aircraft Break Rate		I			D		I		
Not Mission Capable Rate (NMC Rate)	I	I							D
Air Aborts		I							D
Number of Aircraft Fixed in 8 Hours							D	I	
Sorties Flown		I							D
Sorties Scheduled		I							D
Average Hours Per Inspection				D					
Average Turn Time				D					
Direct Labor Rate				D					
Enroute Labor Rate			D						
Home Station Reliability			D						
Maintenance Air Aborts			D						
Number of Aircraft Fixed in 4 Hours							D		
Recur Discrepancy Rate							D		
Training Reliability			D						
Average Possessed Aircraft			I				I		I
Cannibalization Rate		I					I	I	
Aircraft Sortie Duration		I					I		
Hours Flown		I		I					

Table 9. Continues

Aircraft Maintenance Performance Factor	Researcher(s)								
	Davis & Walker (1992)	Jung (1991)	Gilliland (1990)	Diener & Hood (1980)	Allison (1999)	Beabout (2003)	Commenator (2001)	Oliver (2001)	Faas (2003)
Late Take-Offs		I		I					
Number of Maintenance Personnel Assigned				I				I	
Possesed Hours		I							I
Aircraft Breaks		I							
Aircraft Fix Rate		I							
Awaiting Maintenance Discrepancies			I						
Awaiting Parts Discrepancies			I						
Base Self Sufficiency			I						
Cancellation Rate		I							
Cancellations		I							
Cannibalizations		I							
Flying Hours Allocated				I					
Full Mission Capable Rate (FMC Rate)		I							
Hours Flown vs Allocated				I					
Late Take-Off Rate		I							
Manhours Expended		I							
Manhours Per Sortie		I							
Mean Skill Level of Maintenance Personnel				I					
Number of Aircraft Fixed in 18 Hours		I							
Number of Personnel Assigned vs Authorized				I					
Number of Personnel Authorized Per Aircraft	I								
Partial Mission Capable Maintenance Rate (PMCM Rate)		I							
Partial Mission Capable Rate (PMC Rate)		I							
Partial Mission Capable Supply Rate (PMCS Rate)		I							
Possesed Aircraft		I							
Sorties Attempted		I							

XIX. Appendix "N". Metrics Regarding Fleet Health Delphi Responses

1st Round Responses

These were the initial responses in answering the part of the 2nd investigative question that addresses which metrics capture the long term health of the fleet during the 1st round of the Delphi study.

1. More philosophy: Although I realize there is a valid need for metrics, they are abused in the Air Force. I would first abolish their inclusion in all performance reports. Especially with senior officers; their effectiveness is often quantified by how well they do on their metrics and with major command inspections. This causes us to manage to the metrics instead of the long term health of the fleet. This is especially true of senior leaders (group and wing commanders) who normally are only assigned for one to two years for a given assignment. Anyway, I believe the most important metric is FMC rates. This shows the percentage of aircraft that are normally available to perform their assigned functions--which is where the rubber meets the road. Any other metrics employed should be a subset of FMC Rates and support attainment of better FMC Rates.
2. Late scheduled maintenance, age of the fleet, aircraft utilization.
3. The standard USAF metrics were used (FMC Rate, PMC Rate, etc). Looked at dropped object rates and number of K write-ups to make sure maintenance troops were keeping focus on the job.
4. Percent of TNMCM (Total Non Mission Capable due to Maintenance) time per aircraft or fleet over time. In other words, determine if there is a trend in TNMCM, whether increasing or decreasing. Intuitively, one would think that the

trend would be increasing with airframe hours. Track maintenance discrepancy fix rates over time. In other words, the length of time it takes to change the aircraft from NMC to PMC/FMC (Partially Mission- or Fully Mission-Capable). Intuitively, one would expect an increase in fix rate time as airframe hours increase. This would indicate either growing numbers of discrepancies or an increase in malfunction complexity. Track numbers of discrepancies discovered during phase inspections. One would expect the numbers of discrepancies discovered during phase to increase with airframe hours.

5. 1. Mission Capable Rate, often subject to "fudging" by maintainers but probably the best summary of fleet health, especially when looked at over an extended period of time. 2. Break rate, a fleet that breaks more often is less healthy. Also a good sign if preventative maintenance is working. 3. Delayed Discrepancies or maintenance backlog, how much work is being deferred into the future. This will show if maintenance practices are focused on the immediate future or long term health.
6. Mc rate is an obvious answer but I don't think it the best metric.
7. MC rate--looking at it from all angles--looking at how much of your NMC time is due to supply or due to maintenance, etc... The code 3 break rate (how many sorties out of total land with code three discrepancies). I would think this is a helpful metric because a healthy fleet won't break as much.
8. Average # of possessed aircraft. As aircraft age and require more extensive (i.e. depot level) maintenance, the number of non-possessed aircraft increases, putting more burden on the airframes available. Maintenance scheduling effectiveness -

we MUST prioritize scheduled maintenance accomplishment to ensure long term fleet.

9. I saw many displayed but could not tell you what were important ops concerns centered on UTE rates and monthly sortie/hour production but to guess for the long term I would suggest: NDI stats that result in major repairs such as wing changes Repeat write ups Time to fail stats for parts or subassemblies Number of flights per year conducted with near Max Gross Weight takeoffs (training vs combat time) to quantify higher stress flights and effect on lifespan Phase - # and type of exceptional write-ups discovered.
10. The currently used metrics work if they are interpreted correctly. For example, we too often view a declining MC rate as a problem when it is actually a symptom. More effort should focus on discovering the root causes.
11. Rate of cannibalization. When a squadron has to rob parts out of one jet to keep another one flying they are doing twice as much work as they would have to do if the supply system had the part in the first place. Instead of removing & replacing a bad component, they are forced to remove the bad part, remove the good part from the "rob" jet, install the good part, and install another good part once it becomes available.
12. MC rate TNMCM rate Average Possessed Aircraft (APA) Delayed/Deferred Discrepancies Phase Flow Days Repeat/Recur rate Average Repair Cycle Time Time Compliance Technical Order Backlog Phase Time Distribution Interval These metrics are described either in AFI 21-101 or identified in the 2000 Chief of Staff Logistics Review (CLR) by the Air Force Chief of Staff, General John

Jumper, as important to aircraft long-term fleet.

13. DDs Average -- Indicates how much work we are putting off doing -- may become "must pays." TCTO backlog -- Indicates work level on the horizon that's being staved off -- willl become "must pays" sooner or later. MC rate -- self explanatory. TNMCS rate -- a building queue that will come due. Letter of X's -- -- indicates backlog of pilot RAP (Ready Aircrew) requirements that may become must pays. Extensive LoX's may drive increased sortie production (indicator of good aircrew scheduling where, if it were leveled off, it might become manageable without resorting to sortie surges to make up the difference). Repeat/Recur rate -- indicator of good/bad troubleshooting (we're doing each maintenance job twice or more to achieve the same end).
14. % of scheduled sorties flown that accomplished full mission objectives. The bottom line isn't how many tails are available or for how much time they're available, but how many of the scheduled missions a commander wanted to fly in a week or month he was able to see flown and how effective those missions were. Of course, if a mission wasn't successful for reasons other than MX (pilot error, weather, act of God, for example), that should be excluded somehow.
15. Scheduling effectiveness: do we fly the aircraft we scheduled to fly? Maintenance scheduling effectiveness: Do we follow our scheduled maintenance plan or are we sacrificing maintenance to other operational needs? Repeat / recurr rates: When we fix aircraft, are we fixing them right the first time? MICAP rates: Are we getting the parts we need to fix the aircraft in a timely fashion?
16. Ground abort rate plus MND rate-- ensuring that you count every time a jet is

aborted for a mx reason once the pilot has stepped to it, and every line that is cancelled for a MND. I think this gives a realistic idea of how healthy your jets really are.

XX. Appendix "O". Metrics Regarding Maintenance Effectiveness Delphi Responses

1st Round Responses

These were the initial responses in answering the part of the 2nd investigative question that addresses which metrics capture the maintenance effectiveness to meet unit sortie production goals during the 1st round of the Delphi study.

1. I'm not sure what they call it in aircraft, but we have what is called a WRF. It is a listing of all the discrepancies against a piece of equipment or missile site. I would track the ratio of WRF size to number of aircraft assigned. The reason I say this is it would show how much outstanding work exists over time. This can be an indicator of maintenance effectiveness and the burden on maintenance. I say this because we are often juggling priorities in the maintenance effort. Many times we will scramble to repair one thing that, at least on the books, will make a weapon FMC and forego fixing all the other minor discrepancies that are outstanding because we have other high priority work to perform. This can result in an extensive backlog, which is created by pressure to manage to the metrics, as mentioned before. This metric would certainly show how much we are foregoing the maintenance philosophy of "find and fix". Again, we should perform all the repairs possible while we have the piece of equipment at our disposal or else bigger problems will arise.
2. MC
3. The standard USAF metrics were used (FMC Rate, NMC Rate, etc). These numbers are less useful if you have 5 different configurations of jets.

4. Track maintenance discrepancy fix rates over time. In other words, the length of time it takes to change the aircraft from NMCM to PMC/FMC (Partially Mission- or Fully Mission-Capable). Intuitively, one would expect an increase in fix rate time as airframe hours increase. This would indicate either growing numbers of discrepancies or an increase in malfunction complexity. On-time departure rates, and ground or in-flight abort rates due to maintenance could be an indicator of maintenance quality. Track schedule "fill" rates. In other words, the difference between how many sorties are scheduled and how many aircraft are available to fly the sorties. 100% would mean all scheduled sorties were filled with available aircraft.
5. 1. Fix rate/recovery rate, How fast can you effectively do maintenance 2. Phase backlog, will there be enough phase hours to meet all the flying goals
6. None.
7. Flying Scheduling Effectiveness Rate--captures how closely you were able to follow your agreed upon schedule.
8. Repeat/recur rate - taking the time and allocating the resources to fix the problem right the first time is mandatory to meet sortie production goals. CANN rate - the more we have to CANN, the harder it is to meet sortie production goals - CANNing a part takes twice as long as replacing it with a supply item.
9. Mission capable rate Time to acquire replacement parts - to evaluate efficiency of logistics chain time to repair deficiency once parts on hand- to evaluate unit mx effectiveness and skill number of repeat write ups- to evaluate unit mx effectiveness and skill can not duplicate (CND) rates - to trend perceived vs actual

deficiencies as well as comment on trouble shooting/repair effectiveness Phase scheduling - mx management effectiveness Phase time completion stats - mx management effectiveness or identification of life-cycle problems Delivery rates - mx management effectiveness Comparison of number of schedule change requests to number accepted / rejected / accomplished

10. Weekly - monthly scheduled maintenance completion...was it accomplished on time? If not, why? AWM rate Manning
11. Sortie completion rate = sorties flown / sorties schedule.
12. Fix rate (specifically, 8-hr) Abort rate Break rate Cannibalization rate Mission Capable (MICAP) Parts Repeat rate Recur rate
13. DDs Average -- Indicates how much work we are putting off doing -- may become "must pays." TCTO backlog -- Indicates work level on the horizon that's being staved off -- willl become "must pays" sooner or later. MC rate -- self explanatory. TNMCS rate -- may be indicator of bad troubleshooting and is building a queue that will come due. Repeat/Recur rate -- indicator of good/bad troubleshooting (we're doing each maintenance job twice or more to achieve the same end.
14. I guess the differentiator would be the time period over which each stat is measured, but again the bottom line is how many mission did a commander need to fly and how many was he/she able to.
15. # aircraft scheduled for the day's flying schedule / # aircraft FMC: This is a good indicator of how well you are meeting each day's sortie production goals (without making radical scheduling changes or pulling planes out of you butt). This ratio

should be produced no later than 2 hours prior to the first launch. A value of 1 or lower is a good indicator of how prepared you are for daily flying. A value greater than 1 is bad!

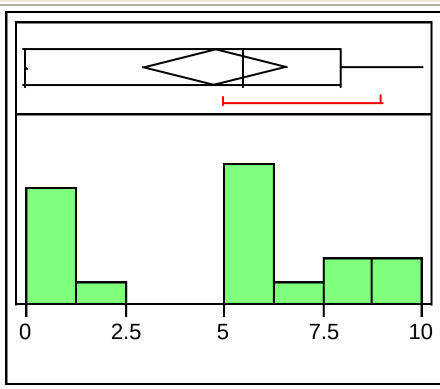
16. Ground abort rate plus MND rate-- ensuring that you count every time a jet is aborted for a mx reason once the pilot has stepped to it, and every line that is cancelled for a MND. I think this gives a realistic idea of how healthy your jets really are.

XXI. Appendix “P”. Box – Plots for 2nd Investigative Question’s Results

Box Plots for Metrics Concerning Long Term Health of the Fleet

Below are the box plots for the responses concerning the one part of the 2nd investigative question. The responses are presented sorted by the mean in descending order.

Q2AO



Quantiles

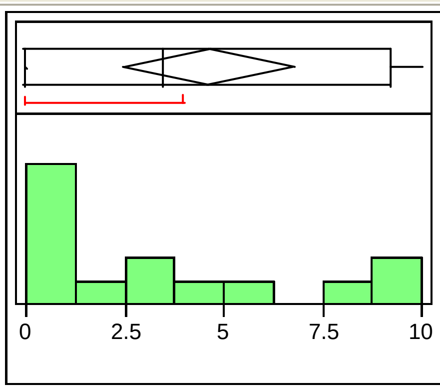
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	8.000
50.0%	median	5.500
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	4.7777778
Std Dev	3.5571892
Std Err Mean	0.8384375
upper 95% Mean	6.5467263
lower 95% Mean	3.0088292
N	18

Figure 251. Box Plot for Repeat Recur Rate

Q2AI



Quantiles

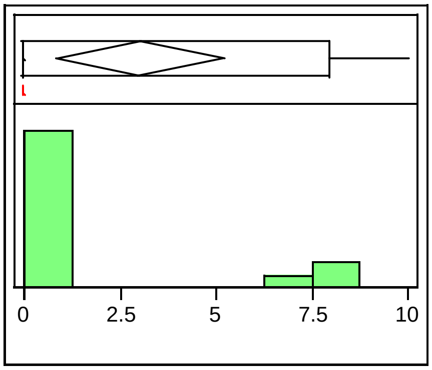
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	9.250
50.0%	median	3.500
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	4.6666667
Std Dev	4.2564829
Std Err Mean	1.0032627
upper 95% Mean	6.7833658
lower 95% Mean	2.5499675
N	18

Figure 252. Box Plot for MC Rate

Q2AQ



Quantiles

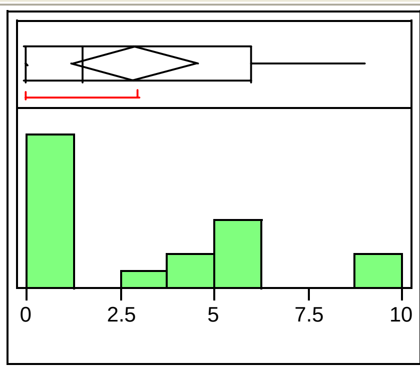
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	8.000
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	3.0555556
Std Dev	4.2767803
Std Err Mean	1.0080468
upper 95% Mean	5.1823484
lower 95% Mean	0.9287628
N	18

Figure 253. Box Plot for Time Each Aircraft Spends Broken

Q2AC



Quantiles

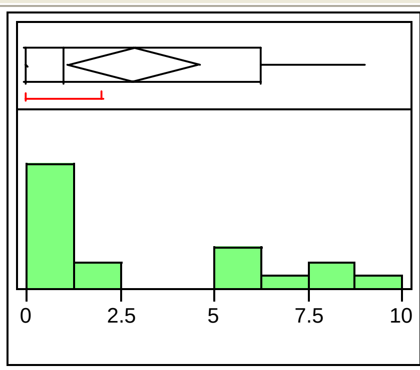
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		9.0000
75.0%	quartile	6.0000
50.0%	median	1.5000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.8888889
Std Dev	3.3057684
Std Err Mean	0.7791771
upper 95% Mean	4.5328088
lower 95% Mean	1.2449689
N	18

Figure 254. Box Plot for Break Rate

Q2AD



Quantiles

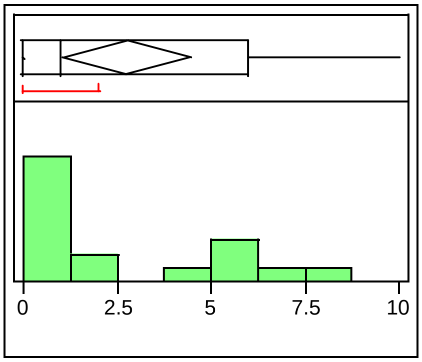
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		8.1000
75.0%	quartile	6.2500
50.0%	median	1.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.8888889
Std Dev	3.4451823
Std Err Mean	0.8120373
upper 95% Mean	4.6021377
lower 95% Mean	1.17564
N	18

Figure 255. Box Plot for Cann Rate

Q2AK



Quantiles

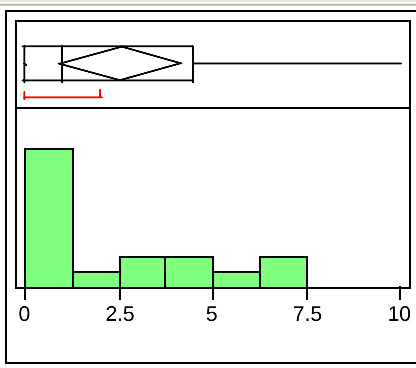
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		8.200
75.0%	quartile	6.000
50.0%	median	1.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.7777778
Std Dev	3.3877905
Std Err Mean	0.7985099
upper 95% Mean	4.4624863
lower 95% Mean	1.0930692
N	18

Figure 256. Box Plot for Number of Discrepancies During Phase

Q2AE



Quantiles

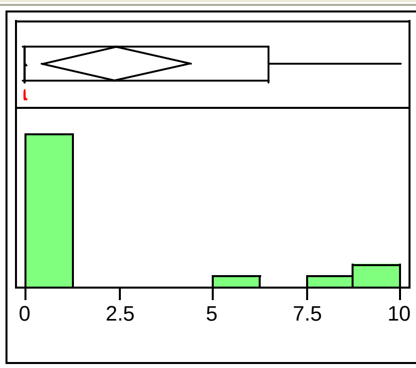
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		7.300
75.0%	quartile	4.500
50.0%	median	1.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.5555556
Std Dev	3.1664087
Std Err Mean	0.7463297
upper 95% Mean	4.1301735
lower 95% Mean	0.9809376
N	18

Figure 257. Box Plot for Ground Abort Rate

Q2AR



Quantiles

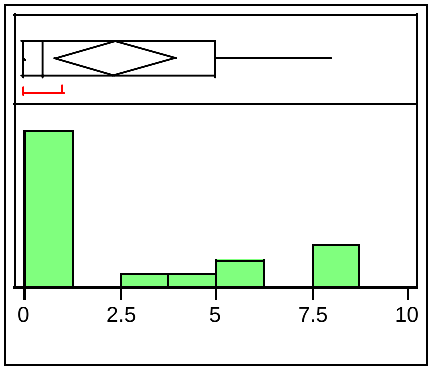
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	6.500
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.4444444
Std Dev	3.8839371
Std Err Mean	0.9154528
upper 95% Mean	4.3758809
lower 95% Mean	0.513008
N	18

Figure 258. Box Plot for TNMCM

Q2AL



Quantiles

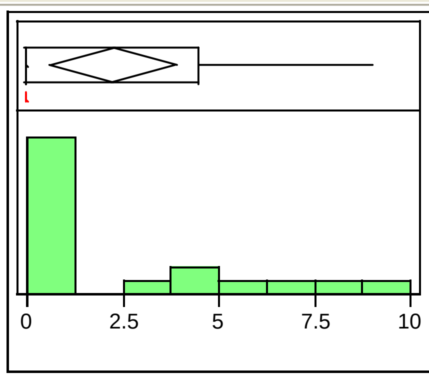
100.0%	maximum	8.0000
99.5%		8.0000
97.5%		8.0000
90.0%		8.0000
75.0%	quartile	5.0000
50.0%	median	0.5000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.3888889
Std Dev	3.1274663
Std Err Mean	0.7371509
upper 95% Mean	3.9441413
lower 95% Mean	0.8336365
N	18

Figure 259. Box Plot for Number of Delayed Discrepancies

Q2AM



Quantiles

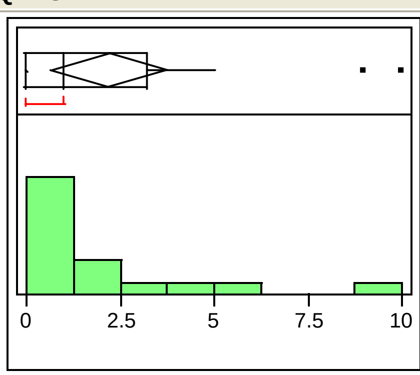
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		8.1000
75.0%	quartile	4.5000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.2777778
Std Dev	3.2322921
Std Err Mean	0.7618586
upper 95% Mean	3.8851588
lower 95% Mean	0.6703967
N	18

Figure 260. Box Plot for Phase Flow Days

Q2AG



Quantiles

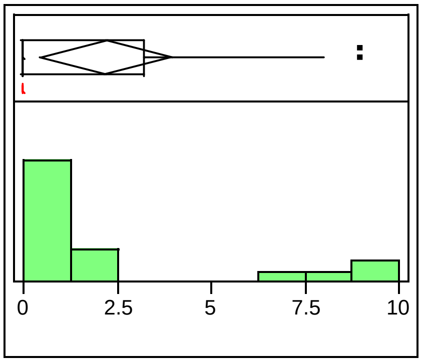
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	3.250
50.0%	median	1.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.2222222
Std Dev	3.0400378
Std Err Mean	0.7165438
upper 95% Mean	3.7339975
lower 95% Mean	0.710447
N	18

Figure 261. Box Plot for Maintenance Scheduling Effectiveness Rate

Q2AP



Quantiles

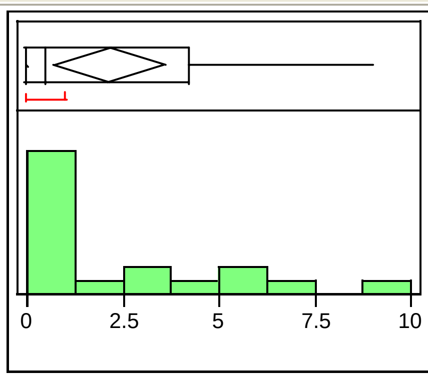
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		9.0000
75.0%	quartile	3.2500
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.2222222
Std Dev	3.4223411
Std Err Mean	0.8066535
upper 95% Mean	3.9241124
lower 95% Mean	0.5203321
N	18

Figure 262. Box Plot for TCTO Backlog

Q2AF



Quantiles

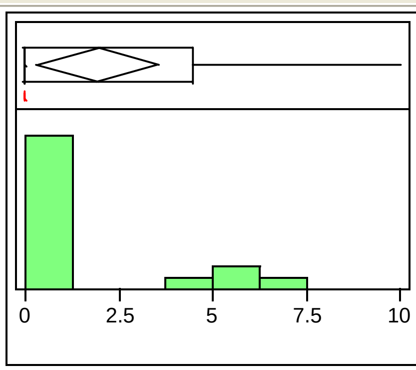
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		7.2000
75.0%	quartile	4.2500
50.0%	median	0.5000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.1666667
Std Dev	2.8127859
Std Err Mean	0.66298
upper 95% Mean	3.5654322
lower 95% Mean	0.7679011
N	18

Figure 263. Box Plot for Maintenance Discrepancy Fix Rates

Q2AS



Quantiles

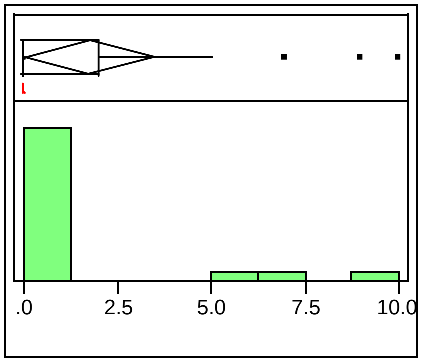
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		7.300
75.0%	quartile	4.500
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	1.9444444
Std Dev	3.1710496
Std Err Mean	0.7474236
upper 95% Mean	3.5213703
lower 95% Mean	0.3675186
N	18

Figure 264. Box Plot for UTE Rate

Q2AA



Quantiles

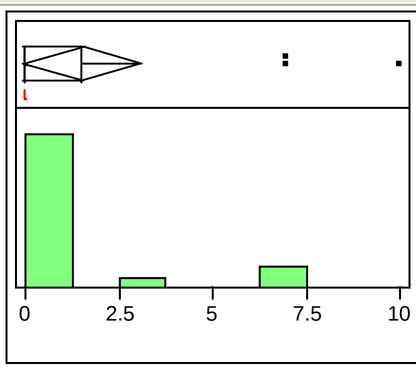
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	2.000
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	1.7777778
Std Dev	3.4223411
Std Err Mean	0.8066535
upper 95% Mean	3.4796679
lower 95% Mean	0.0758876
N	18

Figure 265. Box Plot for % of Scheduled Sorties that Accomplished Mission

Q2AN



Quantiles

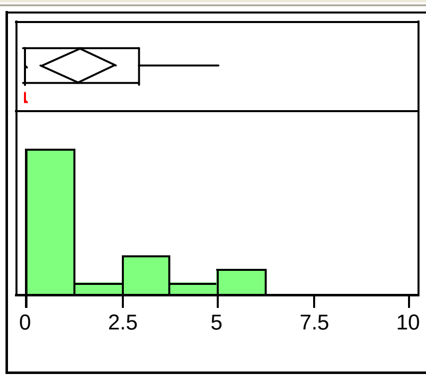
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		7.300
75.0%	quartile	1.500
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	1.5555556
Std Dev	3.1101773
Std Err Mean	0.7330758
upper 95% Mean	3.1022103
lower 95% Mean	0.0089008
N	18

Figure 266. Box Plot for Phase Time Distribution Interval

Q2AH



Quantiles

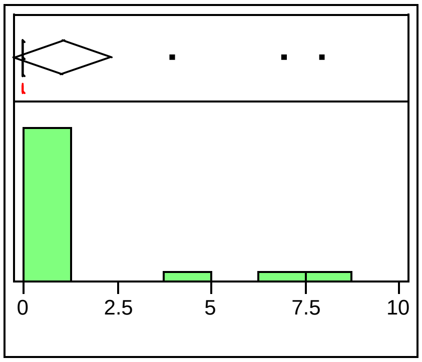
100.0%	maximum	5.0000
99.5%		5.0000
97.5%		5.0000
90.0%		5.0000
75.0%	quartile	3.0000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	1.3888889
Std Dev	1.9140007
Std Err Mean	0.4511343
upper 95% Mean	2.340699
lower 95% Mean	0.4370787
N	18

Figure 267. Box Plot for Maintenance Non-Deliverables

Q2AJ



Quantiles

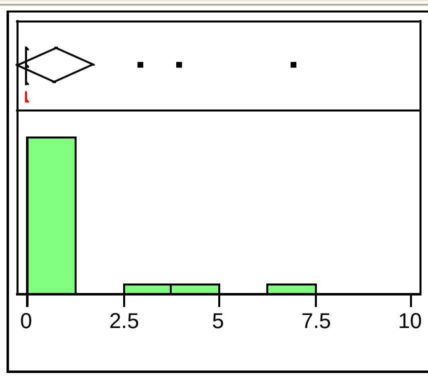
100.0%	maximum	8.0000
99.5%		8.0000
97.5%		8.0000
90.0%		7.1000
75.0%	quartile	0.0000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	1.0555556
Std Dev	2.5315009
Std Err Mean	0.5966805
upper 95% Mean	2.3144413
lower 95% Mean	-0.20333
N	18

Figure 268. Box Plot for Number and Type of Exceptional Write-ups

Q2AB



Quantiles

100.0%	maximum	7.0000
99.5%		7.0000
97.5%		7.0000
90.0%		4.3000
75.0%	quartile	0.0000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

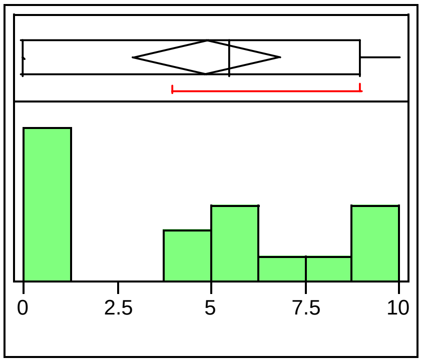
Mean	0.7777778
Std Dev	1.9267637
Std Err Mean	0.4541426
upper 95% Mean	1.7359348
lower 95% Mean	-0.180379
N	18

Figure 269. Box Plot for Amount of Time Taken to Complete Depot Maintenance

Box Plots for Metrics Concerning Maintenance Effectiveness

Below are the box plots for the responses concerning the second part of the 2^{nd} investigative question. The responses are presented sorted by the mean in descending order.

Q3AN



Quantiles

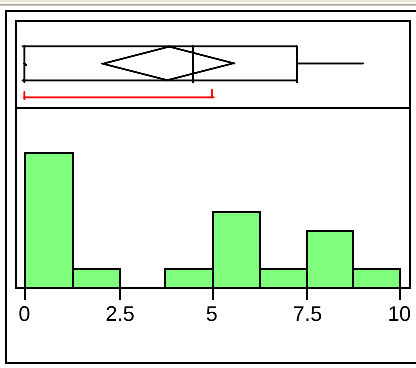
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	9.000
50.0%	median	5.500
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	4.8888889
Std Dev	3.8788854
Std Err Mean	0.914262
upper 95% Mean	6.8178132
lower 95% Mean	2.9599646
N	18

Figure 270. Box Plot for Repeat / Recur Rate

Q3AG



Quantiles

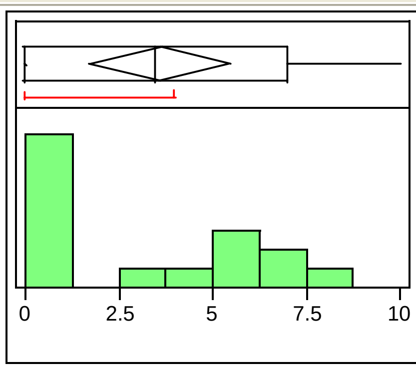
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		8.1000
75.0%	quartile	7.2500
50.0%	median	4.5000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	3.8333333
Std Dev	3.4342565
Std Err Mean	0.809462
upper 95% Mean	5.5411489
lower 95% Mean	2.1255178
N	18

Figure 271. Box Plot for Ground Abort Rate

Q3AK



Quantiles

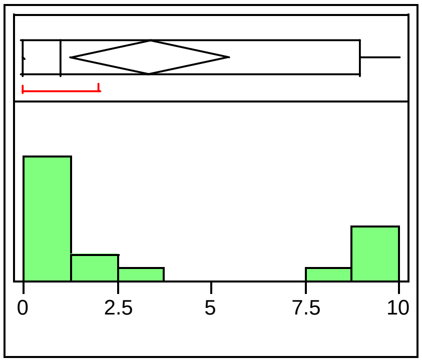
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	7.000
50.0%	median	3.500
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	3.6111111
Std Dev	3.7438403
Std Err Mean	0.8824316
upper 95% Mean	5.4728791
lower 95% Mean	1.7493432
N	18

Figure 272. Box Plot for On-time Departure Rates

Q3AF



Quantiles

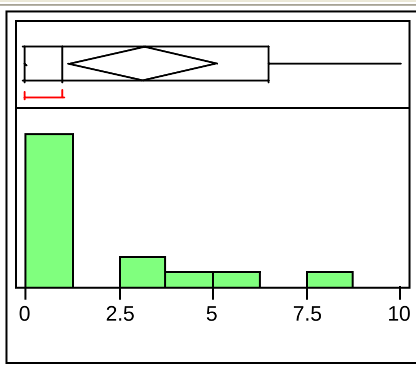
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	9.000
50.0%	median	1.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	3.3888889
Std Dev	4.1887649
Std Err Mean	0.9873014
upper 95% Mean	5.4719127
lower 95% Mean	1.3058651
N	18

Figure 273. Box Plot for Flying Scheduling Effectiveness Rate

Q3AI



Quantiles

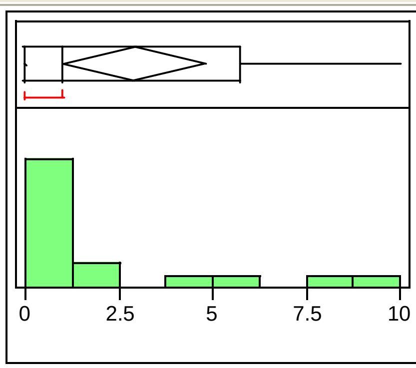
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	6.500
50.0%	median	1.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	3.1666667
Std Dev	3.8843578
Std Err Mean	0.9155519
upper 95% Mean	5.0983123
lower 95% Mean	1.235021
N	18

Figure 274. Box Plot for MC Rate

Q3AH



Quantiles

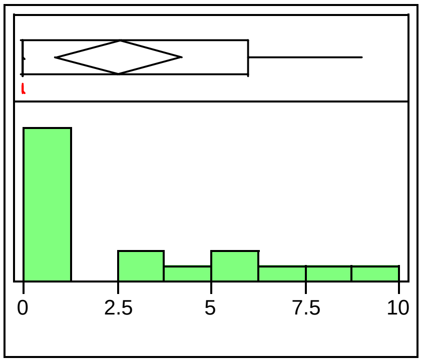
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		10.000
75.0%	quartile	5.750
50.0%	median	1.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.9444444
Std Dev	3.7647314
Std Err Mean	0.8873557
upper 95% Mean	4.8166013
lower 95% Mean	1.0722876
N	18

Figure 275. Box Plot for Maintenance Discrepancy Fix Rates

Q3AE



Quantiles

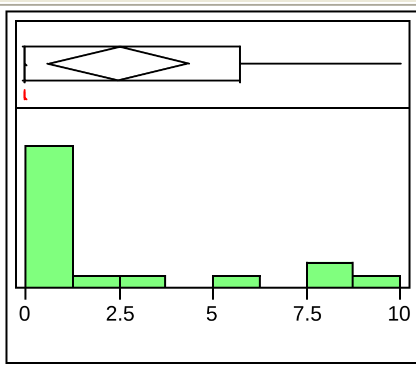
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		8.1000
75.0%	quartile	6.0000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.5555556
Std Dev	3.2759771
Std Err Mean	0.7721552
upper 95% Mean	4.1846607
lower 95% Mean	0.9264505
N	18

Figure 276. Box Plot for Fix Rates

Q3AQ



Quantiles

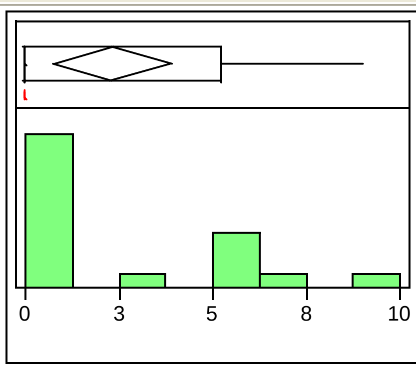
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	5.750
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.5
Std Dev	3.7140433
Std Err Mean	0.8754084
upper 95% Mean	4.3469503
lower 95% Mean	0.6530497
N	18

Figure 277. Box Plot for TNMCM

Q3AA



Quantiles

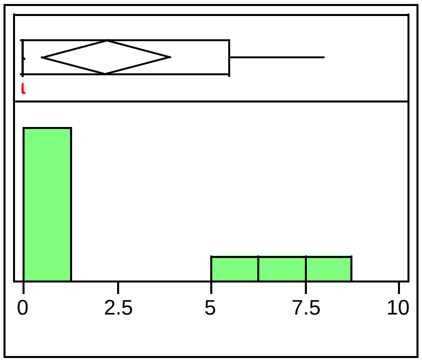
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		7.2000
75.0%	quartile	5.2500
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.3333333
Std Dev	3.1059715
Std Err Mean	0.7320845
upper 95% Mean	3.8778966
lower 95% Mean	0.7887701
N	18

Figure 278. Box Plot for (# of AC Scheduled) / (# FMC) 2 Hours Prior 1st Launch

Q3AB



Quantiles

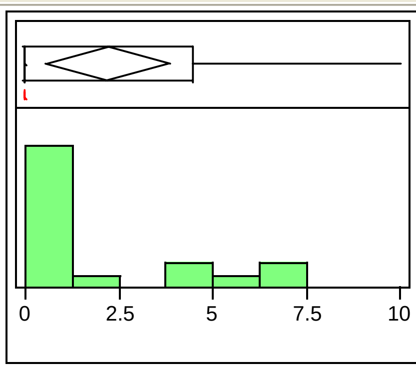
100.0%	maximum	8.0000
99.5%		8.0000
97.5%		8.0000
90.0%		8.0000
75.0%	quartile	5.5000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	2.2222222
Std Dev	3.31761
Std Err Mean	0.7819682
upper 95% Mean	3.8720308
lower 95% Mean	0.5724136
N	18

Figure 279. Box Plot for Cann Rate

Q3AP



Quantiles

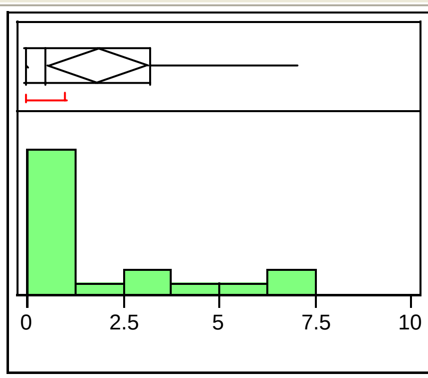
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		7.300
75.0%	quartile	4.500
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	2.2222222
Std Dev	3.2639845
Std Err Mean	0.7693285
upper 95% Mean	3.8453635
lower 95% Mean	0.5990809
N	18

Figure 280. Box Plot for Sortie Completion Rate

Q3AD



Quantiles

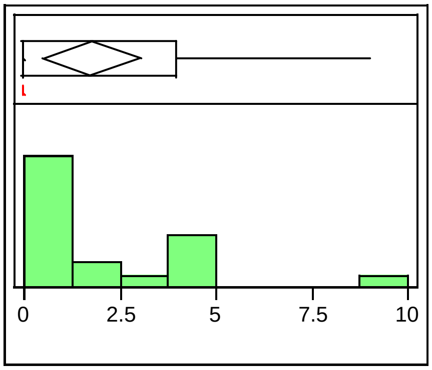
100.0%	maximum	7.0000
99.5%		7.0000
97.5%		7.0000
90.0%		7.0000
75.0%	quartile	3.2500
50.0%	median	0.5000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	1.8888889
Std Dev	2.5411644
Std Err Mean	0.5989582
upper 95% Mean	3.1525802
lower 95% Mean	0.6251976
N	18

Figure 281. Box Plot for Discrepancies Awaiting Maintenance

Q3AM



Quantiles

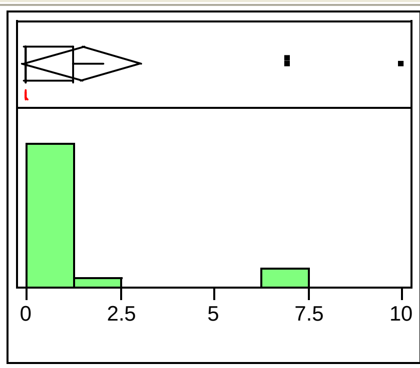
100.0%	maximum	9.0000
99.5%		9.0000
97.5%		9.0000
90.0%		4.5000
75.0%	quartile	4.0000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	1.7777778
Std Dev	2.4865652
Std Err Mean	0.586089
upper 95% Mean	3.0143176
lower 95% Mean	0.541238
N	18

Figure 282. Box Plot for Phase Time Completion Stats

Q3AC



Quantiles

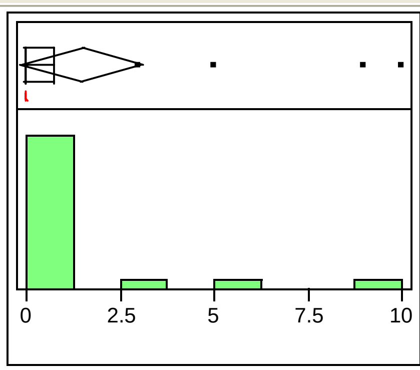
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		7.300
75.0%	quartile	1.250
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	1.5
Std Dev	3.0917347
Std Err Mean	0.7287289
upper 95% Mean	3.0374835
lower 95% Mean	-0.037484
N	18

Figure 283. Box Plot for Comparison of # of Schedule Change Requests to # Accepted / Rejected / Accomplished

Q3AJ



Quantiles

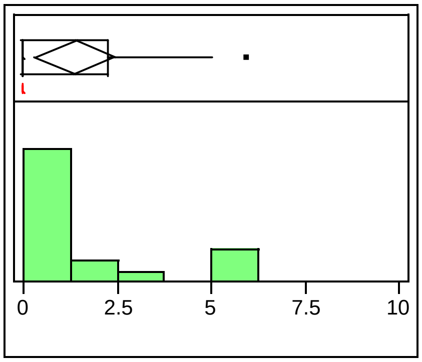
100.0%	maximum	10.000
99.5%		10.000
97.5%		10.000
90.0%		9.100
75.0%	quartile	0.750
50.0%	median	0.000
25.0%	quartile	0.000
10.0%		0.000
2.5%		0.000
0.5%		0.000
0.0%	minimum	0.000

Moments

Mean	1.5
Std Dev	3.203858
Std Err Mean	0.7551566
upper 95% Mean	3.0932411
lower 95% Mean	-0.093241
N	18

Figure 284. Box Plot for Mission Success Rate

Q3AL



Quantiles

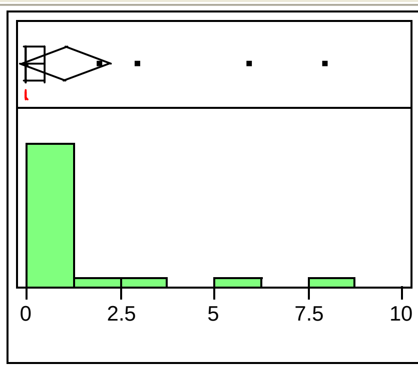
100.0%	maximum	6.0000
99.5%		6.0000
97.5%		6.0000
90.0%		5.1000
75.0%	quartile	2.2500
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	1.3888889
Std Dev	2.0332208
Std Err Mean	0.4792347
upper 95% Mean	2.3999858
lower 95% Mean	0.377792
N	18

Figure 285. Box Plot for Phase Backlog

Q3AO



Quantiles

100.0%	maximum	8.0000
99.5%		8.0000
97.5%		8.0000
90.0%		6.2000
75.0%	quartile	0.5000
50.0%	median	0.0000
25.0%	quartile	0.0000
10.0%		0.0000
2.5%		0.0000
0.5%		0.0000
0.0%	minimum	0.0000

Moments

Mean	1.0555556
Std Dev	2.3382302
Std Err Mean	0.5511261
upper 95% Mean	2.2183301
lower 95% Mean	-0.107219
N	18

Figure 286. Box Plot for Schedule “Fill” Rates

XXII. Appendix "Q". Script: Splitevents.php

```
<?php
$lines = file('c:\phpdev\www\thesis\data\MH2.txt');
$numlines = count($lines);
$string1 = "VENT-ID";
for ($i = 0; $i < $numlines; $i++){
print "i = " . $i . "<br>" ;
$posstart = strpos($lines[$i], $string1);
print "posstart = " . $posstart . "<br>" ;
      if ($posstart != "") {
            $start = $i ;
            print "start = " . $start . "<br>" ;
            for ($j = $i + 1; $j < $numlines ; $j++) {
                  print "j = " . $j . "<br>" ;
                  $posfinish = strpos($lines[$j], $string1);
                  if ($posfinish != "") {
                        $finish = $j - 1 ;
                        $j = $numlines ;
                  } else {
                    $finish = $numlines ;
                  }
            }
      $i = $finish ;
      $text = "" ;
for ($k = $start; $k < $finish - 1; $k++){
      print "string length = " . strlen($lines[$k]) . "<br>";
  if (substr_count($lines[$k], "VERSION DATE:") == 1) $k = $k + 5 ;
      if ((strlen($lines[$k]) > 2) and (substr_count($lines[$k], ". . .
. . . . ") == 0) and (substr_count($lines[$k], "** EQUIP ID:") == 0)
and (substr_count($lines[$k], "FSC        PART NUMBER       SERIAL
NUMBER") == 0) and (substr_count($lines[$k], "INSTALLED:") == 0) and
(substr_count($lines[$k], "REMOVED:") == 0)) {
            $text .= $lines[$k] ;
      }
      print "k = " . $k . "<br>" ;
}
print $text . "<br>" ;
$filename   = "c:/phpdev/www/thesis/data/parsed/2_" . $start . ".txt";
$fp1 = fopen ($filename, "a+");
fwrite($fp1, $text);
fclose($fp1);
      }
}
?>
```

XXIII. Appendix “R”. Script: Parse.php

```
<?php

function converttotime($str) {
      $retstr = str_replace("24", "00", substr($str, 0, 2)) . ":" .
substr($str, 2, 2);
      return $retstr ;
}


$fp1 = fopen ("events.csv", "a+");
$fp2 = fopen ("pwc.csv","a+");
$fp3 = fopen ("ddr.csv","a+");
$fp4 = fopen ("descriptions.csv","a+");
$dir_name = "c:\phpdev\www\\thesis\data\parsed";
$handle=opendir($dir_name) ;
echo "Directory handle:" . $handle . "<br>";
echo "Files:" . "<br>";
while (false !== ($file = readdir($handle))) {
    if ($file != "." && $file != "..") {
      $filename = $dir_name . "\\" . $file ;
      print $filename . "<br>" ;
      // $fp = fopen ($filename,"r");

      $lines = file($filename);
                  $numlines = count($lines);
                  $eventid = substr($lines[1], 0, 9) ;
                  for ($i = 0; $i < $numlines; $i++){
                        $first7 = substr($lines[$i], 0, 7) ;
                        switch ($first7) {
                              case "WCE-SEQ":
                                $wceseq = substr($lines[$i+1], 2, 3) ;
                                $pwc = substr($lines[$i+1], 19, 5) ;
                                // $equipid = str_replace(" ", "",
substr($lines[$i+1], 36, 11)) ;
                                // print $eventid . "<br>" ;
                                // print $equipid . "<br>" ;
                                // print $file . "<br>" ;
                                // print $lines[$i+1] . "<br>" ;
                                //$wuc = substr($lines[$i+1], 54, 5) ;
                                //$sym = substr($lines[$i+1], 70, 1) ;
                                //$srd = substr($lines[$i+1], 88, 3) ;
                                $wce = str_replace(" ", "",
substr($lines[$i+1], 119, 10)) ;
                              //fwrite($fp2, $eventid . "^'" . $wceseq
. "'^'" . $pwc . "'^'" . $equipid . "'^'" . $wuq . "'^'" . $sym . "'^'"
. $srd . "'^'" . $wce . "'\n") ;
                              fwrite($fp2, $eventid . "^" . $wceseq .
"^" . $pwc . "^" . $wce . "\n") ;
                                    break ;
                              case "DDR-SEQ":
                                $ddr = substr($lines[$i+1], 2, 3) ;
```

```
                                $tm = substr($lines[$i+1], 9, 1) ;
                                $cp = substr($lines[$i+1], 12, 1) ;
                                $wuc = substr($lines[$i+1], 15, 5) ;
                                $at = substr($lines[$i+1], 32, 1) ;
                                $wd = substr($lines[$i+1], 35, 1) ;
                                $hm = substr($lines[$i+1], 38, 3) ;
                                $mcc = substr($lines[$i+1], 43, 1) ;
                                $up = substr($lines[$i+1], 46, 2) ;
                                $start =
converttotime(substr($lines[$i+1], 49, 4)) ;
                                $date = substr($lines[$i+1], 54, 5) ;
                                $stop =
converttotime(substr($lines[$i+1], 60, 4)) ;
                                $hrs = substr($lines[$i+1], 68, 3) ;
                                $cs = substr($lines[$i+1], 74, 1) ;
                                $clb = substr($lines[$i+1], 77, 1) ;
                                $ccai = substr($lines[$i+1], 81, 2) ;
                                $empl = substr($lines[$i+1], 86, 6) ;
                                $afsc = substr($lines[$i+1], 93, 5) ;
                                $mds = substr($lines[$i+1], 102, 5) ;
                                $blk = substr($lines[$i+1], 108, 3) ;
                                $serial = substr($lines[$i+1], 112, 10)
;
                                $srd = substr($lines[$i+1], 123, 3) ;
                                    fwrite($fp3, $eventid . "^" .
$wceseq . "^" . $ddr . "^" . $tm . "^" . $cp . "^" . $wuc . "^" . $at .
"^" . $wd . "^" . $hm . "^" . $mcc . "^" . $up . "^" . $start . "^" .
$date . "^" . $stop . "^" . $hrs . "^" . $cs . "^" . $clb . "^" . $ccai
. "^" . $empl . "^" . $afsc . "^" . $mds . "^" . $blk . "^" . $serial .
"^" . $srd . "\n") ;
                                    break ;
                              case "DISCREP":
                                    $description = "" ;
                                    $desc = "" ;
                                    for ($j = $i; $j < $numlines; $j++)
{
                                          if (substr_count($lines[$j],
"WCE-SEQ")) {
                                                $endline = $j ;
                                                $j = $numlines ;
                                          }
                                    }
                                    for ($k = $i; $k < $endline; $k++)
{
                                          $desc .= substr($lines[$k],
13, 60) ;
                                    }
                                    $description = str_replace("\n",
"", $desc) ;
                                    $description = str_replace("\r",
"", $description) ;
                                    fwrite($fp4, $eventid . "^" .
$description . "\n" ) ;
                                    break ;
                              case "EVENT-I":
```

```
                                $equipid = substr($lines[$i+1], 20, 5)
;
                                $cp = substr($lines[$i+1], 35, 1) ;
                                $wuc = substr($lines[$i+1], 43, 5) ;
                                $wd = substr($lines[$i+1], 63, 1) ;
                                $rep = substr($lines[$i+1], 70, 1) ;
                                $sym = substr($lines[$i+1], 92, 1) ;
                                $sortienbr = substr($lines[$i+1], 106,
3) ;
                                $mcc = substr($lines[$i+1], 43, 1) ;
                                $date = substr($lines[$i+1], 122, 9) ;
                                    fwrite($fp1, $eventid . "^" .
$equipid . "^" . $cp . "^" . $wuc . "^" . $wd . "^" . $rep . "^" . $sym
. "^" . $sortienbr . "^" . $mcc . "^" . $date. "\n") ;

                                    break ;
                              default:
                                    break ;
                        }
                  }
            }
      }
fclose($fp1);
fclose($fp2);
fclose($fp3);
fclose($fp4);
?>
```

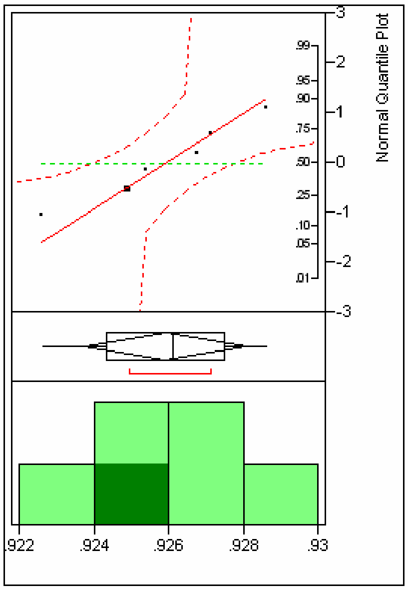
XXIV. Appendix "S". Checking the Normality Assumption in DOE

Output Variable NMCM Rate

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92863
99.5%		0.92863
97.5%		0.92863
90.0%		0.92863
75.0%	quartile	0.92751
50.0%	median	0.92610
25.0%	quartile	0.92436
10.0%		0.92263
2.5%		0.92263
0.5%		0.92263
0.0%	minimum	0.92263

Moments

Mean	0.9259236
Std Dev	0.0020833
Std Err Mean	0.0008505
upper 95% Mean	0.9281099
lower 95% Mean	0.9237373
N	6

Stem and Leaf

Stem	Leaf	Count
928	6	1
928		
927		
927	1	1
926	8	1
926		
925		
925	4	1
924	9	1
924		
923		
923		
922	6	1

922|6 represents 0.9226

Figure 287. Stem and Leaf and Normal Quantile Plot for Treatment 1

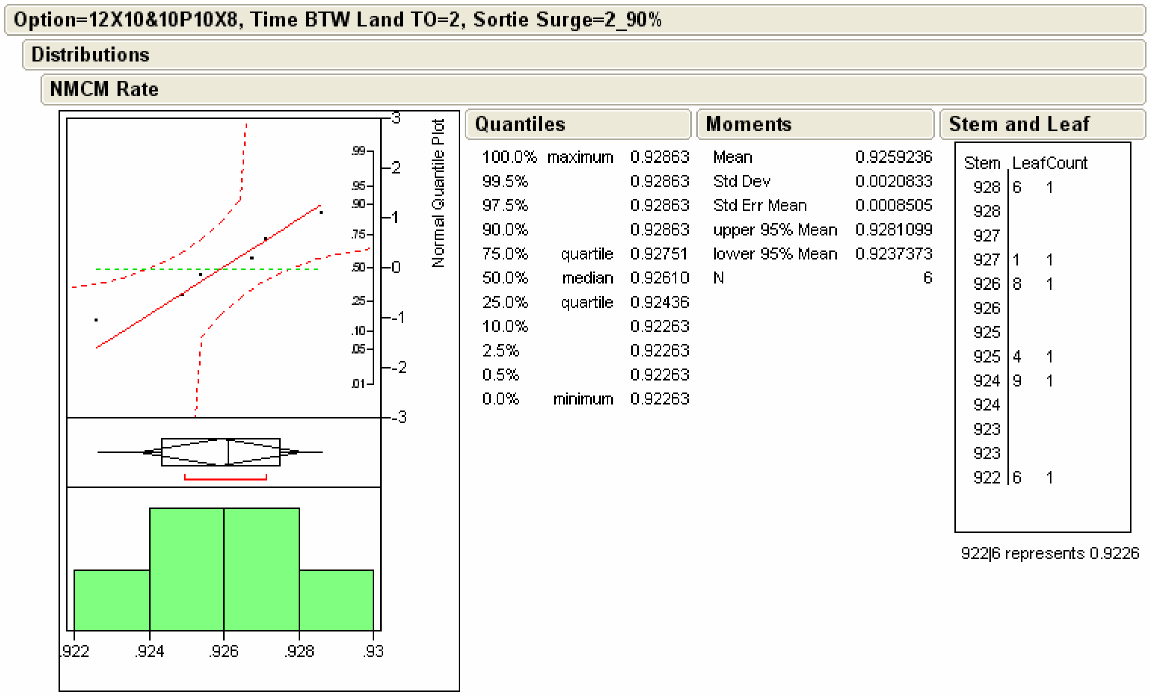


Figure 288. Stem and Leaf and Normal Quantile Plot for Treatment 2

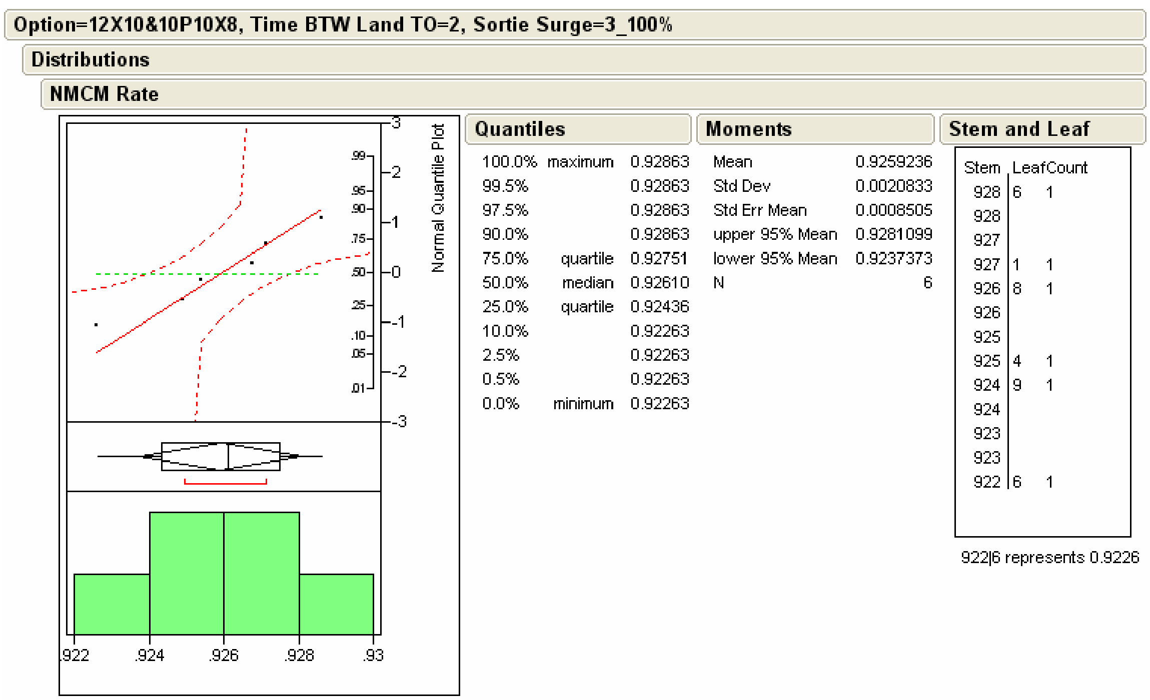
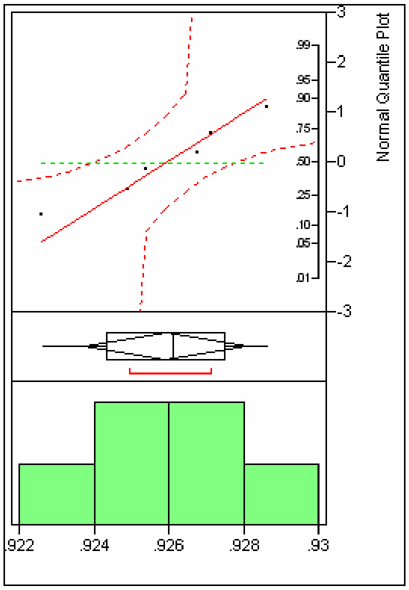


Figure 289. Stem and Leaf and Normal Quantile Plot for Treatment 3

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92863
99.5%		0.92863
97.5%		0.92863
90.0%		0.92863
75.0%	quartile	0.92751
50.0%	median	0.92610
25.0%	quartile	0.92436
10.0%		0.92263
2.5%		0.92263
0.5%		0.92263
0.0%	minimum	0.92263

Moments

Mean	0.9259236
Std Dev	0.0020833
Std Err Mean	0.0008505
upper 95% Mean	0.9281099
lower 95% Mean	0.9237373
N	6

Stem and Leaf

Stem	Leaf	Count
928	6	1
928		
927		
927	1	1
926	8	1
926		
925		
925	4	1
924	9	1
924		
923		
923		
922	6	1

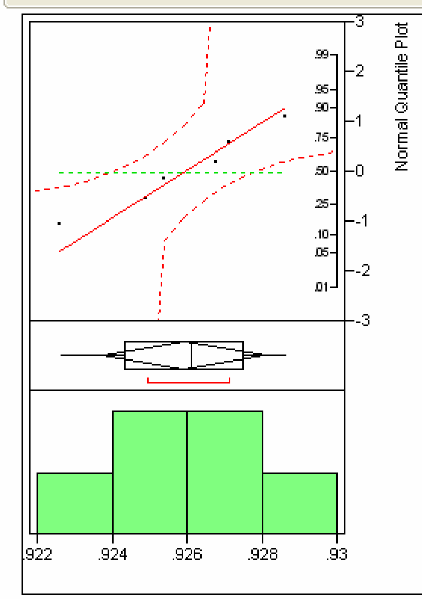
922|6 represents 0.9226

Figure 290. Stem and Leaf and Normal Quantile Plot for Treatment 4

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92863
99.5%		0.92863
97.5%		0.92863
90.0%		0.92863
75.0%	quartile	0.92751
50.0%	median	0.92610
25.0%	quartile	0.92436
10.0%		0.92263
2.5%		0.92263
0.5%		0.92263
0.0%	minimum	0.92263

Moments

Mean	0.9259236
Std Dev	0.0020833
Std Err Mean	0.0008505
upper 95% Mean	0.9281099
lower 95% Mean	0.9237373
N	6

Stem and Leaf

Stem	Leaf	Count
928	6	1
928		
927		
927	1	1
926	8	1
926		
925		
925	4	1
924	9	1
924		
923		
923		
922	6	1

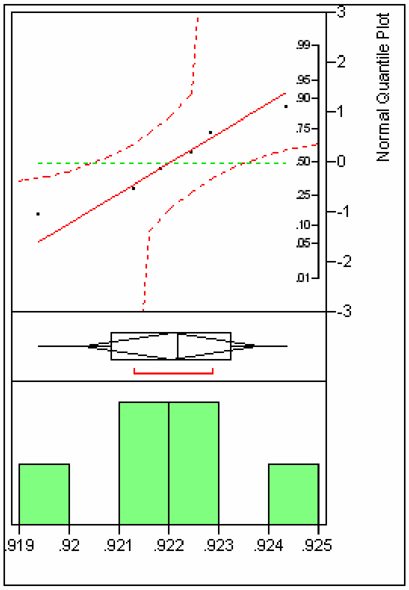
922|6 represents 0.9226

Figure 291. Stem and Leaf and Normal Quantile Plot for Treatment 5

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92437
99.5%		0.92437
97.5%		0.92437
90.0%		0.92437
75.0%	quartile	0.92325
50.0%	median	0.92217
25.0%	quartile	0.92084
10.0%		0.91941
2.5%		0.91941
0.5%		0.91941
0.0%	minimum	0.91941

Moments

Mean	0.9220515
Std Dev	0.001661
Std Err Mean	0.0006781
upper 95% Mean	0.9237946
lower 95% Mean	0.9203083
N	6

Stem and Leaf

Stem	Leaf	Count
924	4	1
923		
923		
922	59	2
922		
921	9	1
921	3	1
920		
920		
919		
919	4	1

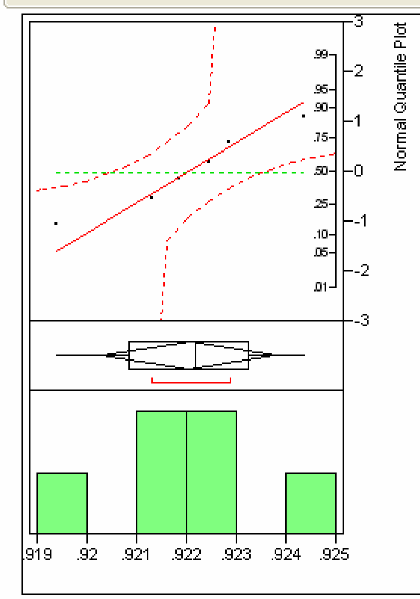
919|4 represents 0.9194

Figure 292. Stem and Leaf and Normal Quantile Plot for Treatment 6

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92437
99.5%		0.92437
97.5%		0.92437
90.0%		0.92437
75.0%	quartile	0.92325
50.0%	median	0.92217
25.0%	quartile	0.92084
10.0%		0.91941
2.5%		0.91941
0.5%		0.91941
0.0%	minimum	0.91941

Moments

Mean	0.9220515
Std Dev	0.001661
Std Err Mean	0.0006781
upper 95% Mean	0.9237946
lower 95% Mean	0.9203083
N	6

Stem and Leaf

Stem	Leaf	Count
924	4	1
923		
923		
922	59	2
922		
921	9	1
921	3	1
920		
920		
919		
919	4	1

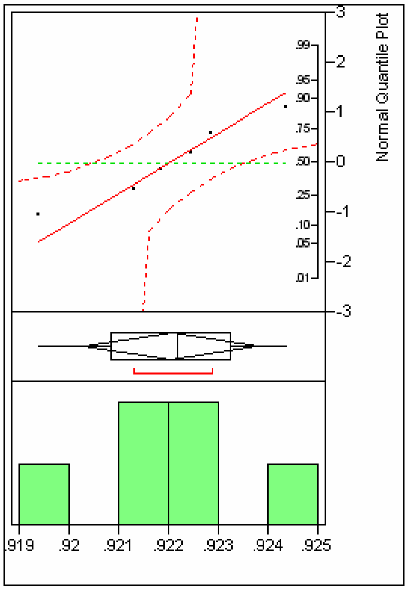
919|4 represents 0.9194

Figure 293. Stem and Leaf and Normal Quantile Plot for Treatment 7

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92437
99.5%		0.92437
97.5%		0.92437
90.0%		0.92437
75.0%	quartile	0.92325
50.0%	median	0.92217
25.0%	quartile	0.92084
10.0%		0.91941
2.5%		0.91941
0.5%		0.91941
0.0%	minimum	0.91941

Moments

Mean	0.9220515
Std Dev	0.001661
Std Err Mean	0.0006781
upper 95% Mean	0.9237946
lower 95% Mean	0.9203083
N	6

Stem and Leaf

Stem	Leaf	Count
924	4	1
923		
923		
922	59	2
922		
921	9	1
921	3	1
920		
920		
919		
919	4	1

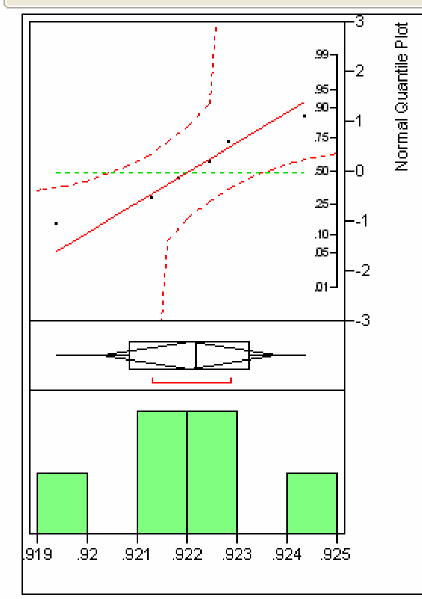
919|4 represents 0.9194

Figure 294. Stem and Leaf and Normal Quantile Plot for Treatment 8

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92437
99.5%		0.92437
97.5%		0.92437
90.0%		0.92437
75.0%	quartile	0.92325
50.0%	median	0.92217
25.0%	quartile	0.92084
10.0%		0.91941
2.5%		0.91941
0.5%		0.91941
0.0%	minimum	0.91941

Moments

Mean	0.9220515
Std Dev	0.001661
Std Err Mean	0.0006781
upper 95% Mean	0.9237946
lower 95% Mean	0.9203083
N	6

Stem and Leaf

Stem	Leaf	Count
924	4	1
923		
923		
922	59	2
922		
921	9	1
921	3	1
920		
920		
919		
919	4	1

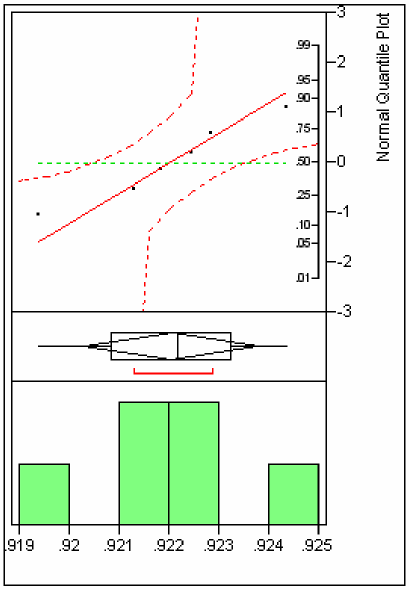
919|4 represents 0.9194

Figure 295. Stem and Leaf and Normal Quantile Plot for Treatment 9

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92437
99.5%		0.92437
97.5%		0.92437
90.0%		0.92437
75.0%	quartile	0.92325
50.0%	median	0.92217
25.0%	quartile	0.92084
10.0%		0.91941
2.5%		0.91941
0.5%		0.91941
0.0%	minimum	0.91941

Moments

Mean	0.9220515
Std Dev	0.001661
Std Err Mean	0.0006781
upper 95% Mean	0.9237946
lower 95% Mean	0.9203083
N	6

Stem and Leaf

Stem	Leaf	Count
924	4	1
923		
923		
922	59	2
922		
921	9	1
921	3	1
920		
920		
919		
919	4	1

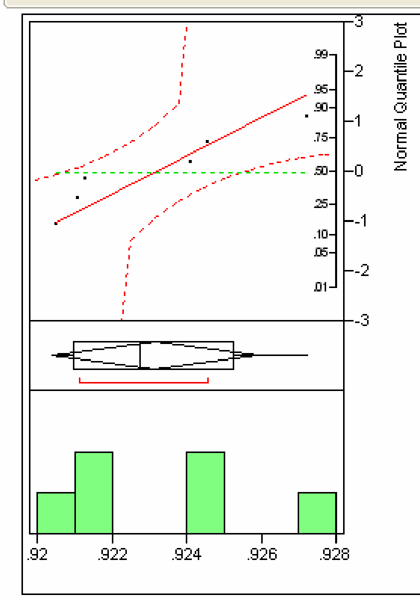
919|4 represents 0.9194

Figure 296. Stem and Leaf and Normal Quantile Plot for Treatment 10

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92725
99.5%		0.92725
97.5%		0.92725
90.0%		0.92725
75.0%	quartile	0.92525
50.0%	median	0.92274
25.0%	quartile	0.92097
10.0%		0.92053
2.5%		0.92053
0.5%		0.92053
0.0%	minimum	0.92053

Moments

Mean	0.9231605
Std Dev	0.0026146
Std Err Mean	0.0010674
upper 95% Mean	0.9259043
lower 95% Mean	0.9204166
N	6

Stem and Leaf

Stem	Leaf	Count
927	2	1
926		
926		
925		
925		
924	6	1
924	2	1
923		
923		
922		
922		
921		
921	13	2
920	5	1

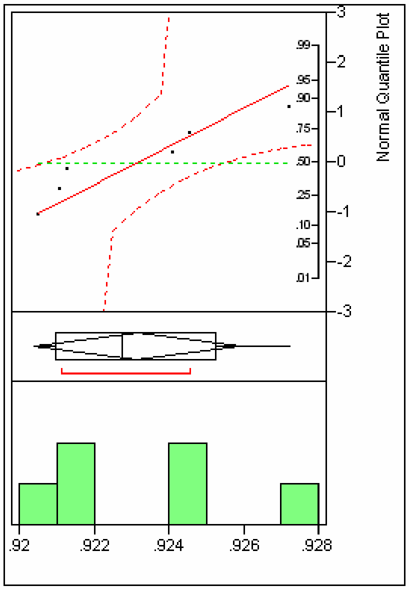
920|5 represents 0.9205

Figure 297. Stem and Leaf and Normal Quantile Plot for Treatment 11

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92725
99.5%		0.92725
97.5%		0.92725
90.0%		0.92725
75.0%	quartile	0.92525
50.0%	median	0.92274
25.0%	quartile	0.92097
10.0%		0.92053
2.5%		0.92053
0.5%		0.92053
0.0%	minimum	0.92053

Moments

Mean	0.9231605
Std Dev	0.0026146
Std Err Mean	0.0010674
upper 95% Mean	0.9259043
lower 95% Mean	0.9204166
N	6

Stem and Leaf

Stem	Leaf	Count
927	2	1
926		
926		
925		
925		
924	6	1
924	2	1
923		
923		
922		
922		
921		
921	13	2
920	5	1

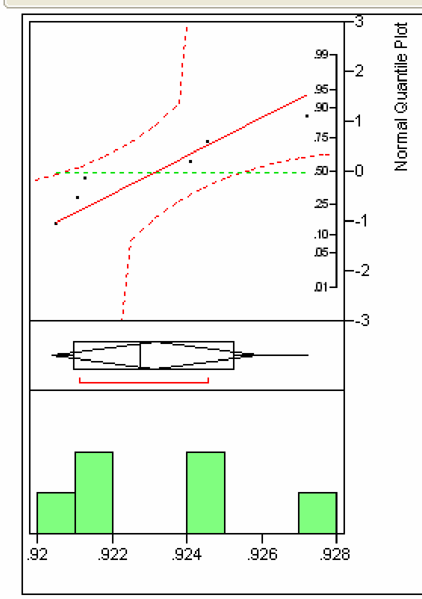
920|5 represents 0.9205

Figure 298. Stem and Leaf and Normal Quantile Plot for Treatment 12

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92725
99.5%		0.92725
97.5%		0.92725
90.0%		0.92725
75.0%	quartile	0.92525
50.0%	median	0.92274
25.0%	quartile	0.92097
10.0%		0.92053
2.5%		0.92053
0.5%		0.92053
0.0%	minimum	0.92053

Moments

Mean	0.9231605
Std Dev	0.0026146
Std Err Mean	0.0010674
upper 95% Mean	0.9259043
lower 95% Mean	0.9204166
N	6

Stem and Leaf

Stem	Leaf	Count
927	2	1
926		
926		
925		
925		
924	6	1
924	2	1
923		
923		
922		
922		
921		
921	13	2
920	5	1

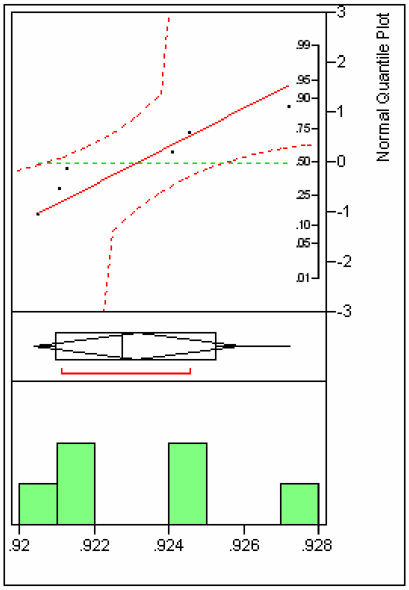
920|5 represents 0.9205

Figure 299. Stem and Leaf and Normal Quantile Plot for Treatment 13

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92725
99.5%		0.92725
97.5%		0.92725
90.0%		0.92725
75.0%	quartile	0.92525
50.0%	median	0.92274
25.0%	quartile	0.92097
10.0%		0.92053
2.5%		0.92053
0.5%		0.92053
0.0%	minimum	0.92053

Moments

Mean	0.9231605
Std Dev	0.0026146
Std Err Mean	0.0010674
upper 95% Mean	0.9259043
lower 95% Mean	0.9204166
N	6

Stem and Leaf

Stem	Leaf	Count
927	2	1
926		
926		
925		
925		
924	6	1
924	2	1
923		
923		
922		
922		
921		
921	13	2
920	5	1

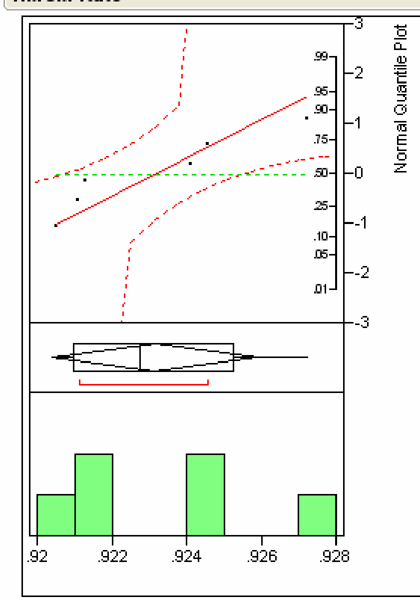
920|5 represents 0.9205

Figure 300. Stem and Leaf and Normal Quantile Plot for Treatment 14

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92725
99.5%		0.92725
97.5%		0.92725
90.0%		0.92725
75.0%	quartile	0.92525
50.0%	median	0.92274
25.0%	quartile	0.92097
10.0%		0.92053
2.5%		0.92053
0.5%		0.92053
0.0%	minimum	0.92053

Moments

Mean	0.9231605
Std Dev	0.0026146
Std Err Mean	0.0010674
upper 95% Mean	0.9259043
lower 95% Mean	0.9204166
N	6

Stem and Leaf

Stem	Leaf	Count
927	2	1
926		
926		
925		
925		
924	6	1
924	2	1
923		
923		
922		
922		
921		
921	13	2
920	5	1

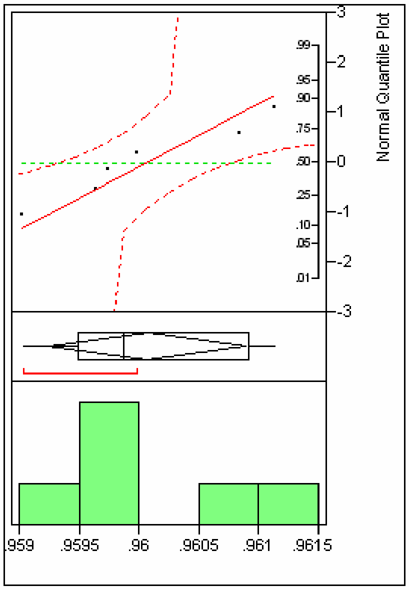
920|5 represents 0.9205

Figure 301. Stem and Leaf and Normal Quantile Plot for Treatment 15

Option=3WMF, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.96114
99.5%		0.96114
97.5%		0.96114
90.0%		0.96114
75.0%	quartile	0.96092
50.0%	median	0.95987
25.0%	quartile	0.95950
10.0%		0.95904
2.5%		0.95904
0.5%		0.95904
0.0%	minimum	0.95904

Moments

Mean	0.9600682
Std Dev	0.0007861
Std Err Mean	0.0003209
upper 95% Mean	0.9608932
lower 95% Mean	0.9592433
N	6

Stem and Leaf

Stem	Leaf	Count
961	1	1
960	8	1
960		
960		
960		
960	0	1
959	8	1
959	7	1
959		
959		
959	0	1

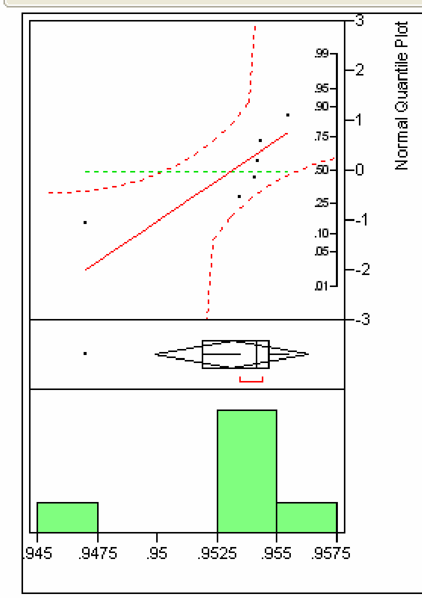
959|0 represents 0.9590

Figure 302. Stem and Leaf and Normal Quantile Plot for Treatment 16

Option=3WMF, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95548
99.5%		0.95548
97.5%		0.95548
90.0%		0.95548
75.0%	quartile	0.95467
50.0%	median	0.95417
25.0%	quartile	0.95187
10.0%		0.94708
2.5%		0.94708
0.5%		0.94708
0.0%	minimum	0.94708

Moments

Mean	0.9531293
Std Dev	0.0030345
Std Err Mean	0.0012388
upper 95% Mean	0.9563138
lower 95% Mean	0.9499448
N	6

Stem and Leaf

Stem	Leaf	Count
955	5	1
954	124	3
953	5	1
952		
951		
950		
949		
948		
947	1	1

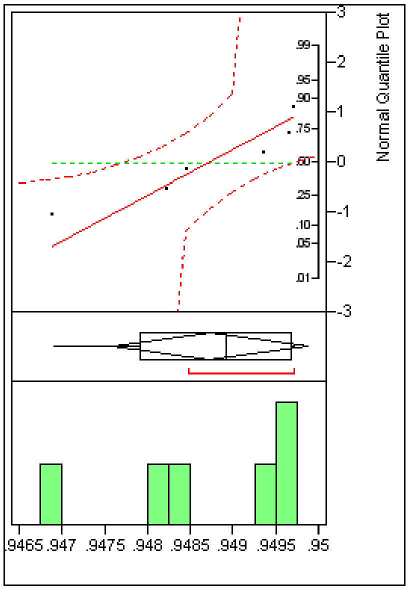
947|1 represents 0.9471

Figure 303. Stem and Leaf and Normal Quantile Plot for Treatment 17

Option=3WMF, Time BTW Land TO=2, Sortie Surge=3_100%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94973
99.5%		0.94973
97.5%		0.94973
90.0%		0.94973
75.0%	quartile	0.94968
50.0%	median	0.94892
25.0%	quartile	0.94791
10.0%		0.94690
2.5%		0.94690
0.5%		0.94690
0.0%	minimum	0.94690

Moments

Mean	0.9487299
Std Dev	0.0010886
Std Err Mean	0.0004444
upper 95% Mean	0.9498723
lower 95% Mean	0.9475874
N	6

Stem and Leaf

Stem	Leaf	Count
949	77	2
949	4	1
949		
949		
948		
948		
948	5	1
948	2	1
948		
947		
947		
947		
947		
947		
946	9	1

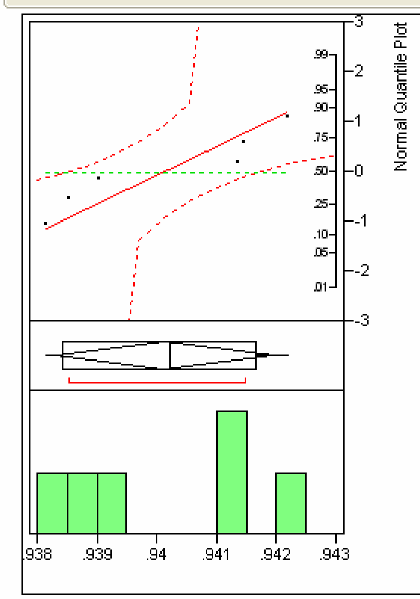
946|9 represents 0.9469

Figure 304. Stem and Leaf and Normal Quantile Plot for Treatment 18

Option=3WMF, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94220
99.5%		0.94220
97.5%		0.94220
90.0%		0.94220
75.0%	quartile	0.94165
50.0%	median	0.94022
25.0%	quartile	0.93844
10.0%		0.93816
2.5%		0.93816
0.5%		0.93816
0.0%	minimum	0.93816

Moments

Mean	0.9401327
Std Dev	0.0017449
Std Err Mean	0.0007123
upper 95% Mean	0.9419639
lower 95% Mean	0.9383016
N	6

Stem and Leaf

Stem	Leaf	Count
942	2	1
941	5	1
941	4	1
940		
940		
939		
939	1	1
938	5	1
938	2	1

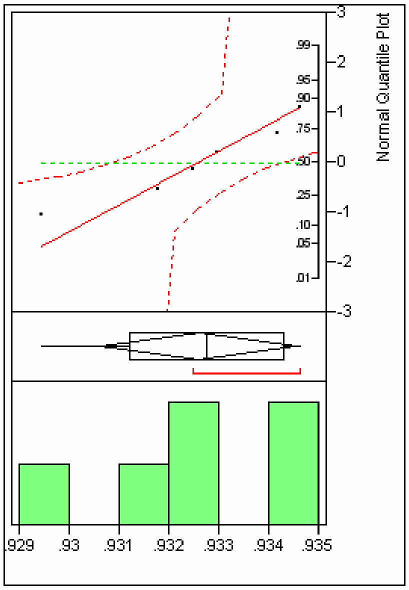
938|2 represents 0.9382

Figure 305. Stem and Leaf and Normal Quantile Plot for Treatment 19

Option=3WMF, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.93465
99.5%		0.93465
97.5%		0.93465
90.0%		0.93465
75.0%	quartile	0.93431
50.0%	median	0.93275
25.0%	quartile	0.93122
10.0%		0.92946
2.5%		0.92946
0.5%		0.92946
0.0%	minimum	0.92946

Moments

Mean	0.9326001
Std Dev	0.0018651
Std Err Mean	0.0007614
upper 95% Mean	0.9345574
lower 95% Mean	0.9306428
N	6

Stem and Leaf

Stem	Leaf	Count
934	6	1
934	2	1
933		
933	0	1
932	5	1
932		
931	8	1
931		
930		
930		
929	5	1

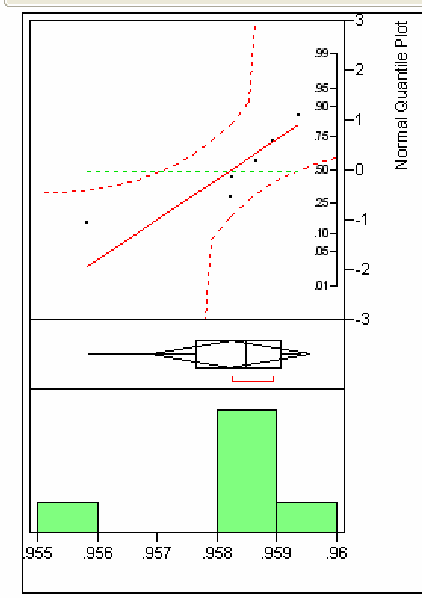
929|5 represents 0.9295

Figure 306. Stem and Leaf and Normal Quantile Plot for Treatment 20

Option=3WMF, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95939
99.5%		0.95939
97.5%		0.95939
90.0%		0.95939
75.0%	quartile	0.95906
50.0%	median	0.95848
25.0%	quartile	0.95766
10.0%		0.95585
2.5%		0.95585
0.5%		0.95585
0.0%	minimum	0.95585

Moments

Mean	0.9582344
Std Dev	0.0012423
Std Err Mean	0.0005072
upper 95% Mean	0.9595381
lower 95% Mean	0.9569307
N	6

Stem and Leaf

Stem	Leaf	Count
959	4	1
958	79	2
958	33	2
957		
957		
956		
956		
955	9	1

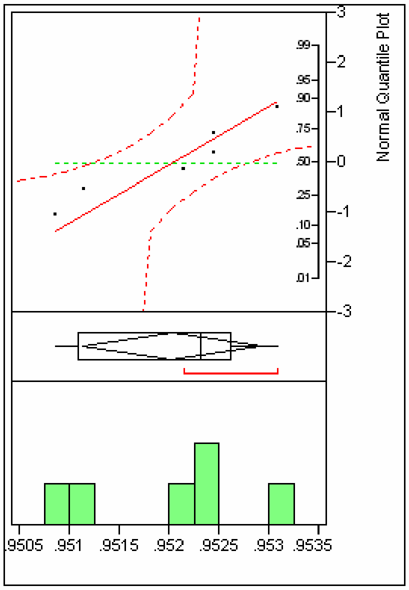
955|9 represents 0.9559

Figure 307. Stem and Leaf and Normal Quantile Plot for Treatment 21

Option=3WMF, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95309
99.5%		0.95309
97.5%		0.95309
90.0%		0.95309
75.0%	quartile	0.95262
50.0%	median	0.95231
25.0%	quartile	0.95109
10.0%		0.95087
2.5%		0.95087
0.5%		0.95087
0.0%	minimum	0.95087

Moments

Mean	0.9520351
Std Dev	0.0008529
Std Err Mean	0.0003482
upper 95% Mean	0.9529301
lower 95% Mean	0.95114
N	6

Stem and Leaf

Stem	Leaf	Count
953	1	1
952		
952		
952	55	2
952	2	1
952		
951		
951		
951		
951	2	1
951		
950	9	1

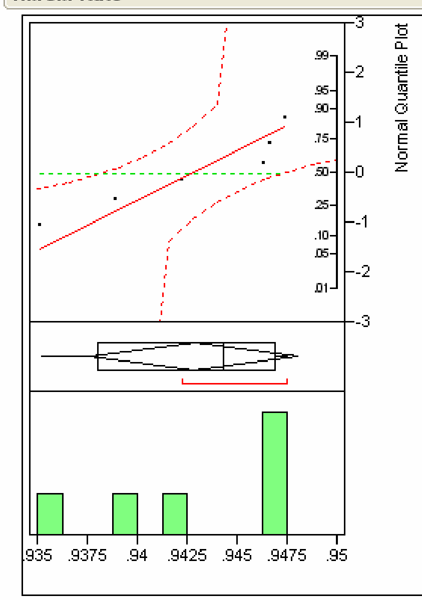
950|9 represents 0.9509

Figure 308. Stem and Leaf and Normal Quantile Plot for Treatment 22

Option=3WMF, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94749
99.5%		0.94749
97.5%		0.94749
90.0%		0.94749
75.0%	quartile	0.94692
50.0%	median	0.94434
25.0%	quartile	0.93803
10.0%		0.93522
2.5%		0.93522
0.5%		0.93522
0.0%	minimum	0.93522

Moments

Mean	0.942849
Std Dev	0.0049567
Std Err Mean	0.0020235
upper 95% Mean	0.9480507
lower 95% Mean	0.9376474
N	6

Stem and Leaf

Stem	Leaf	Count
947	5	1
946	47	2
945		
944		
943		
942	3	1
941		
940		
939	0	1
938		
937		
936		
935	2	1

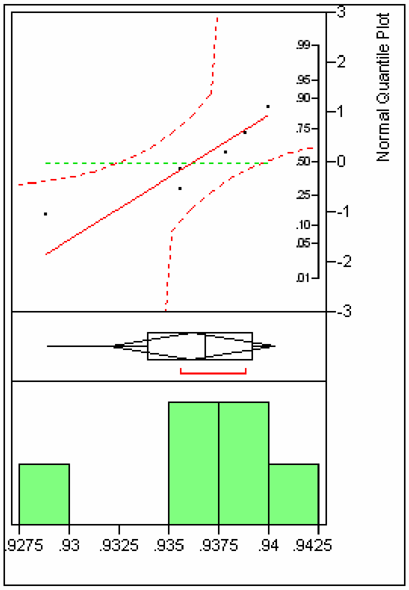
935|2 represents 0.9352

Figure 309. Stem and Leaf and Normal Quantile Plot for Treatment 23

Option=3WMF, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94000
99.5%		0.94000
97.5%		0.94000
90.0%		0.94000
75.0%	quartile	0.93917
50.0%	median	0.93679
25.0%	quartile	0.93393
10.0%		0.92891
2.5%		0.92891
0.5%		0.92891
0.0%	minimum	0.92891

Moments

Mean	0.936164
Std Dev	0.0039596
Std Err Mean	0.0016165
upper 95% Mean	0.9403194
lower 95% Mean	0.9320087
N	6

Stem and Leaf

Stem	Leaf	Count
940	0	1
939		
938	9	1
937	9	1
936		
935	67	2
934		
933		
932		
931		
930		
929		
928	9	1

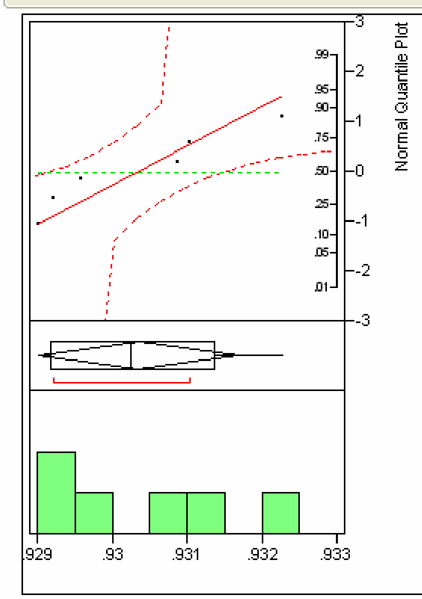
928|9 represents 0.9289

Figure 310. Stem and Leaf and Normal Quantile Plot for Treatment 24

Option=3WMF, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.93227
99.5%		0.93227
97.5%		0.93227
90.0%		0.93227
75.0%	quartile	0.93135
50.0%	median	0.93025
25.0%	quartile	0.92918
10.0%		0.92903
2.5%		0.92903
0.5%		0.92903
0.0%	minimum	0.92903

Moments

Mean	0.9303473
Std Dev	0.0012674
Std Err Mean	0.0005174
upper 95% Mean	0.9316773
lower 95% Mean	0.9290172
N	6

Stem and Leaf

Stem	Leaf	Count
932	3	1
931		
931	0	1
930	9	1
930		
929	6	1
929	02	2

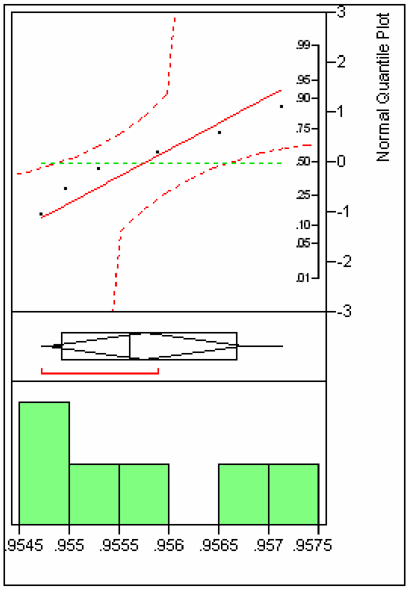
929|0 represents 0.9290

Figure 311. Stem and Leaf and Normal Quantile Plot for Treatment 25

Option=3WMF, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95714
99.5%		0.95714
97.5%		0.95714
90.0%		0.95714
75.0%	quartile	0.95668
50.0%	median	0.95560
25.0%	quartile	0.95492
10.0%		0.95473
2.5%		0.95473
0.5%		0.95473
0.0%	minimum	0.95473

Moments

Mean	0.9557639
Std Dev	0.0009362
Std Err Mean	0.0003822
upper 95% Mean	0.9567465
lower 95% Mean	0.9547814
N	6

Stem and Leaf

Stem	Leaf	Count
957	1	1
956		
956		
956	5	1
956		
956		
955	9	1
955		
955		
955	3	1
955	0	1
954		
954	7	1

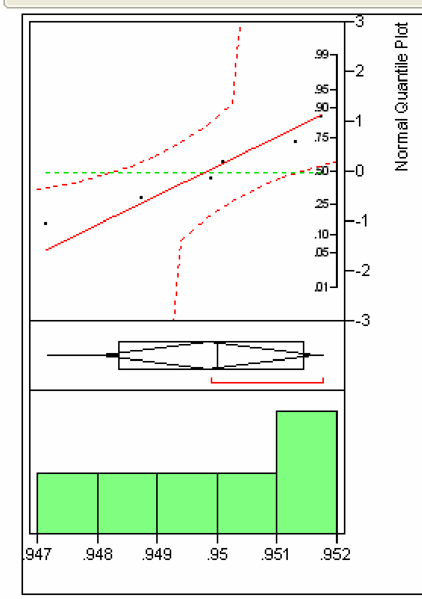
954|7 represents 0.9547

Figure 312. Stem and Leaf and Normal Quantile Plot for Treatment 26

Option=3WMF, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95177
99.5%		0.95177
97.5%		0.95177
90.0%		0.95177
75.0%	quartile	0.95144
50.0%	median	0.95002
25.0%	quartile	0.94835
10.0%		0.94717
2.5%		0.94717
0.5%		0.94717
0.0%	minimum	0.94717

Moments

Mean	0.9498415
Std Dev	0.0016936
Std Err Mean	0.0006914
upper 95% Mean	0.9516189
lower 95% Mean	0.9480642
N	6

Stem and Leaf

Stem	Leaf	Count
951	8	1
951	3	1
950		
950	1	1
949	9	1
949		
948	7	1
948		
947		
947	2	1

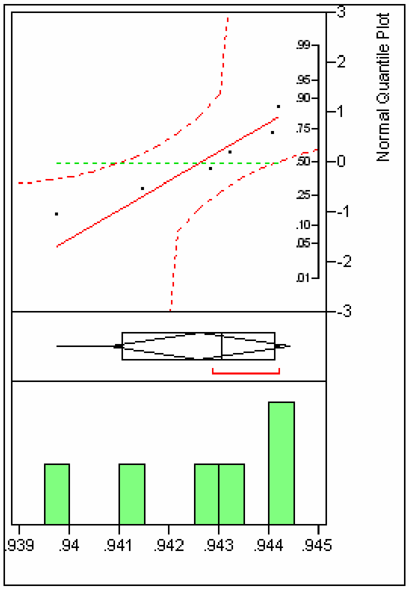
947|2 represents 0.9472

Figure 313. Stem and Leaf and Normal Quantile Plot for Treatment 27

Option=3WMF, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94421
99.5%		0.94421
97.5%		0.94421
90.0%		0.94421
75.0%	quartile	0.94413
50.0%	median	0.94306
25.0%	quartile	0.94106
10.0%		0.93976
2.5%		0.93976
0.5%		0.93976
0.0%	minimum	0.93976

Moments

Mean	0.9426167
Std Dev	0.001709
Std Err Mean	0.0006977
upper 95% Mean	0.9444103
lower 95% Mean	0.9408232
N	6

Stem and Leaf

Stem	Leaf	Count
944	12	2
943		
943	3	1
942	9	1
942		
941	5	1
941		
940		
940		
939	8	1

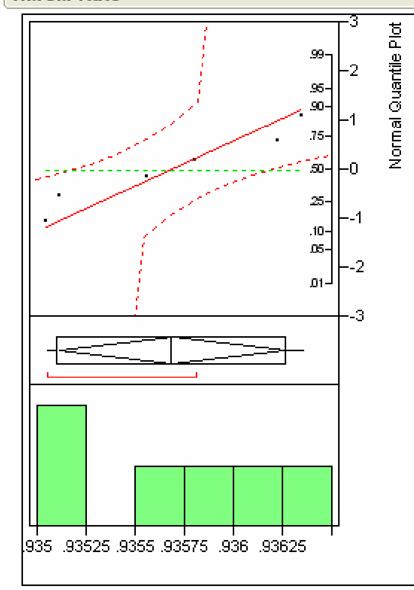
939|8 represents 0.9398

Figure 314. Stem and Leaf and Normal Quantile Plot for Treatment 28

Option=3WMF, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.93636
99.5%		0.93636
97.5%		0.93636
90.0%		0.93636
75.0%	quartile	0.93626
50.0%	median	0.93569
25.0%	quartile	0.93510
10.0%		0.93505
2.5%		0.93505
0.5%		0.93505
0.0%	minimum	0.93505

Moments

Mean	0.9356875
Std Dev	0.0005484
Std Err Mean	0.0002239
upper 95% Mean	0.936263
lower 95% Mean	0.9351121
N	6

Stem and Leaf

Stem	Leaf	Count
9363	6	1
9362	3	1
9361		
9360		
9359		
9358	1	1
9357		
9356		
9355	6	1
9354		
9353		
9352		
9351	2	1
9350	5	1

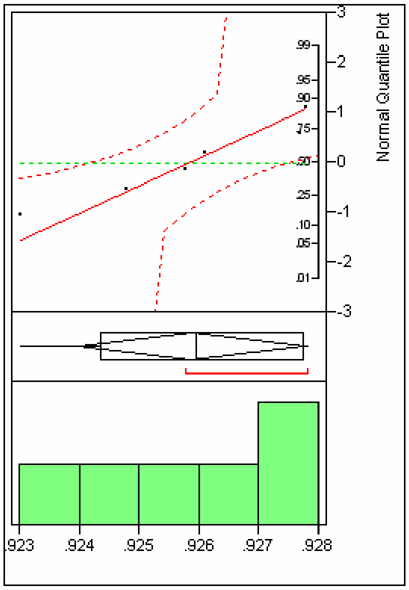
9350|5 represents 0.93505

Figure 315. Stem and Leaf and Normal Quantile Plot for Treatment 29

Option=3WMF, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.92782
99.5%		0.92782
97.5%		0.92782
90.0%		0.92782
75.0%	quartile	0.92774
50.0%	median	0.92595
25.0%	quartile	0.92436
10.0%		0.92303
2.5%		0.92303
0.5%		0.92303
0.0%	minimum	0.92303

Moments

Mean	0.9258791
Std Dev	0.0018135
Std Err Mean	0.0007404
upper 95% Mean	0.9277823
lower 95% Mean	0.923976
N	6

Stem and Leaf

Stem	Leaf	Count
927	78	2
927		
926		
926	1	1
925	8	1
925		
924	8	1
924		
923		
923	0	1

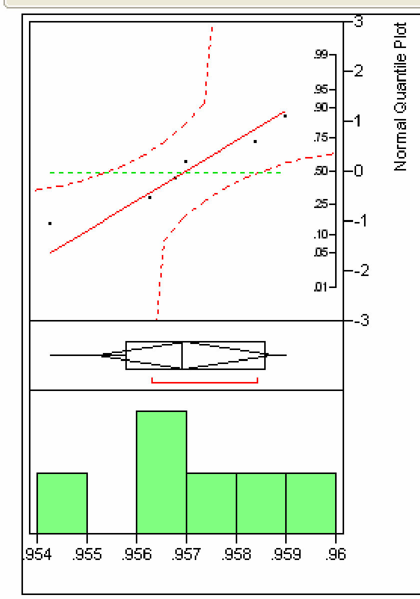
923|0 represents 0.9230

Figure 316. Stem and Leaf and Normal Quantile Plot for Treatment 30

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95900
99.5%		0.95900
97.5%		0.95900
90.0%		0.95900
75.0%	quartile	0.95856
50.0%	median	0.95690
25.0%	quartile	0.95579
10.0%		0.95428
2.5%		0.95428
0.5%		0.95428
0.0%	minimum	0.95428

Moments

Mean	0.9569659
Std Dev	0.0016705
Std Err Mean	0.000682
upper 95% Mean	0.958719
lower 95% Mean	0.9552129
N	6

Stem and Leaf

Stem	Leaf	Count
959	0	1
958		
958	4	1
957		
957	0	1
956	8	1
956	3	1
955		
955		
954		
954	3	1

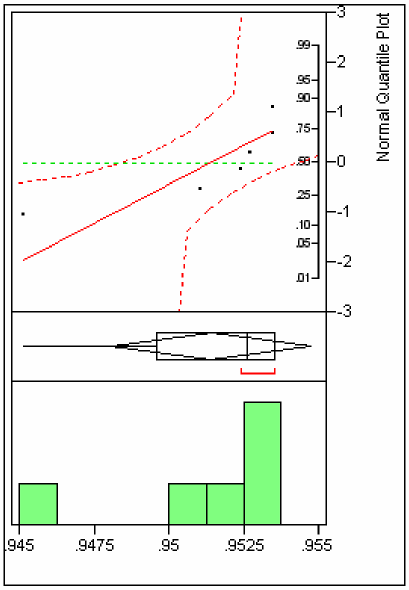
954|3 represents 0.9543

Figure 317. Stem and Leaf and Normal Quantile Plot for Treatment 31

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95352
99.5%		0.95352
97.5%		0.95352
90.0%		0.95352
75.0%	quartile	0.95352
50.0%	median	0.95260
25.0%	quartile	0.94959
10.0%		0.94516
2.5%		0.94516
0.5%		0.94516
0.0%	minimum	0.94516

Moments

Mean	0.9514129
Std Dev	0.0031914
Std Err Mean	0.0013029
upper 95% Mean	0.9547621
lower 95% Mean	0.9480637
N	6

Stem and Leaf

Stem	Leaf	Count
953	55	2
952	48	2
951	1	1
950		
949		
948		
947		
946		
945	2	1

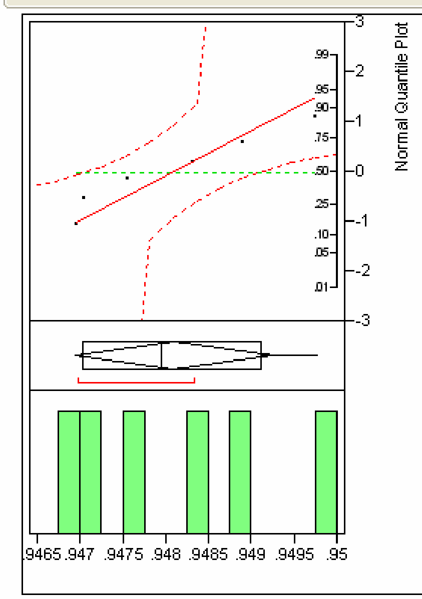
945|2 represents 0.9452

Figure 318. Stem and Leaf and Normal Quantile Plot for Treatment 32

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=3_100%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94976
99.5%		0.94976
97.5%		0.94976
90.0%		0.94976
75.0%	quartile	0.94912
50.0%	median	0.94795
25.0%	quartile	0.94703
10.0%		0.94697
2.5%		0.94697
0.5%		0.94697
0.0%	minimum	0.94697

Moments

Mean	0.9480983
Std Dev	0.0011089
Std Err Mean	0.0004527
upper 95% Mean	0.949262
lower 95% Mean	0.9469346
N	6

Stem and Leaf

Stem	Leaf	Count
949	8	1
949		
949		
949		
949		
948	9	1
948		
948		
948	3	1
948		
947		
947	6	1
947		
947		
947	00	2

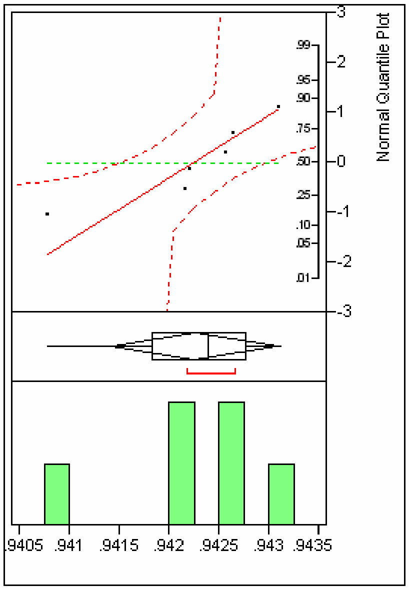
947|0 represents 0.9470

Figure 319. Stem and Leaf and Normal Quantile Plot for Treatment 33

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94312
99.5%		0.94312
97.5%		0.94312
90.0%		0.94312
75.0%	quartile	0.94278
50.0%	median	0.94240
25.0%	quartile	0.94183
10.0%		0.94079
2.5%		0.94079
0.5%		0.94079
0.0%	minimum	0.94079

Moments

Mean	0.9422573
Std Dev	0.0007945
Std Err Mean	0.0003244
upper 95% Mean	0.9430911
lower 95% Mean	0.9414235
N	6

Stem and Leaf

Stem	Leaf	Count
943	1	1
942		
942	67	2
942		
942	22	2
942		
941		
941		
941		
941		
941		
940	8	1

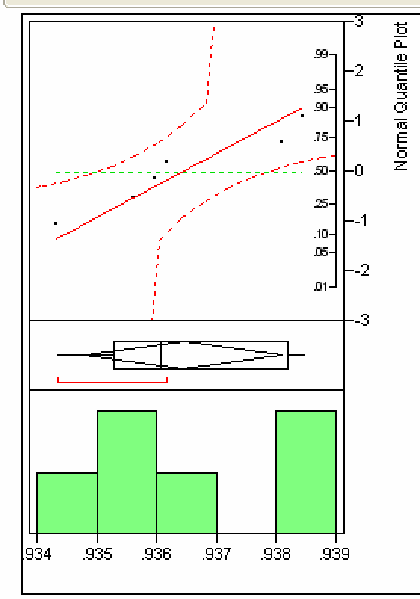
940|8 represents 0.9408

Figure 320. Stem and Leaf and Normal Quantile Plot for Treatment 34

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.93847
99.5%		0.93847
97.5%		0.93847
90.0%		0.93847
75.0%	quartile	0.93819
50.0%	median	0.93607
25.0%	quartile	0.93530
10.0%		0.93435
2.5%		0.93435
0.5%		0.93435
0.0%	minimum	0.93435

Moments

Mean	0.9364451
Std Dev	0.0015608
Std Err Mean	0.0006372
upper 95% Mean	0.9380831
lower 95% Mean	0.9348072
N	6

Stem and Leaf

Stem	Leaf	Count
938	5	1
938	1	1
937		
937		
936		
936	02	2
935	6	1
935		
934		
934	3	1

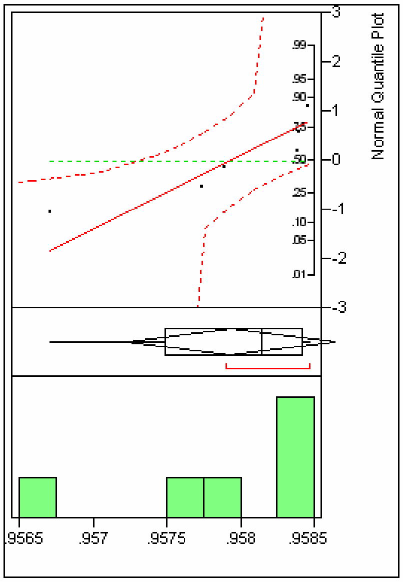
934|3 represents 0.9343

Figure 321. Stem and Leaf and Normal Quantile Plot for Treatment 35

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95847
99.5%		0.95847
97.5%		0.95847
90.0%		0.95847
75.0%	quartile	0.95842
50.0%	median	0.95815
25.0%	quartile	0.95749
10.0%		0.95671
2.5%		0.95671
0.5%		0.95671
0.0%	minimum	0.95671

Moments

Mean	0.9579374
Std Dev	0.0006696
Std Err Mean	0.0002734
upper 95% Mean	0.9586402
lower 95% Mean	0.9572347
N	6

Stem and Leaf

Stem	Leaf	Count
9584	17	2
9583	9	1
9582		
9581		
9580		
9579	0	1
9578		
9577	4	1
9576		
9575		
9574		
9573		
9572		
9571		
9570		
9569		
9568		
9567	1	1

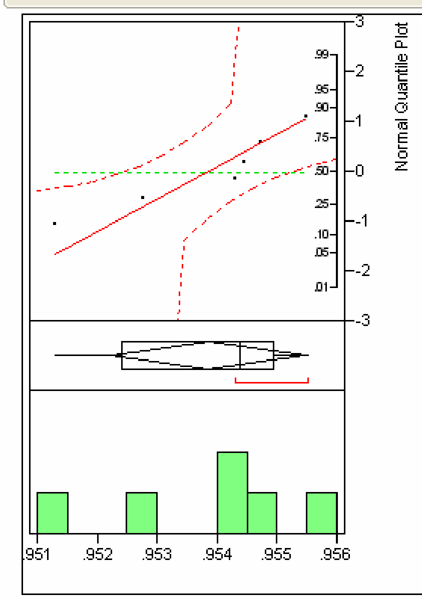
9567|1 represents 0.95671

Figure 322. Stem and Leaf and Normal Quantile Plot for Treatment 36

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95552
99.5%		0.95552
97.5%		0.95552
90.0%		0.95552
75.0%	quartile	0.95494
50.0%	median	0.95439
25.0%	quartile	0.95242
10.0%		0.95131
2.5%		0.95131
0.5%		0.95131
0.0%	minimum	0.95131

Moments

Mean	0.9538571
Std Dev	0.0015348
Std Err Mean	0.0006266
upper 95% Mean	0.9554678
lower 95% Mean	0.9522464
N	6

Stem and Leaf

Stem	Leaf	Count
955	5	1
955		
954	57	2
954	3	1
953		
953		
952	8	1
952		
951		
951	3	1

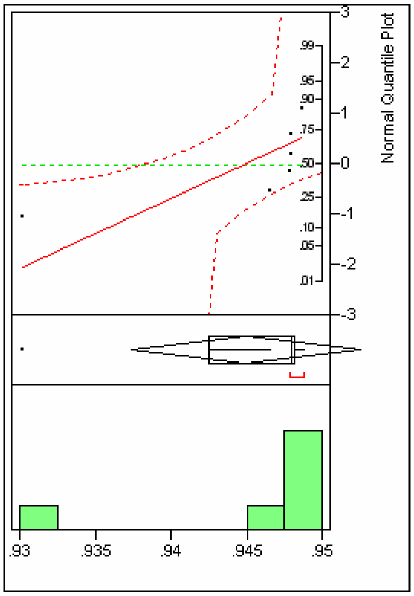
951|3 represents 0.9513

Figure 323. Stem and Leaf and Normal Quantile Plot for Treatment 37

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94876
99.5%		0.94876
97.5%		0.94876
90.0%		0.94876
75.0%	quartile	0.94822
50.0%	median	0.94794
25.0%	quartile	0.94250
10.0%		0.93027
2.5%		0.93027
0.5%		0.93027
0.0%	minimum	0.93027

Moments

Mean	0.9449205
Std Dev	0.0072109
Std Err Mean	0.0029438
upper 95% Mean	0.9524878
lower 95% Mean	0.9373531
N	6

Stem and Leaf

Stem	Leaf	Count
94	8889	4
94	7	1
94		
94		
94		
93		
93		
93		
93		
93	0	1

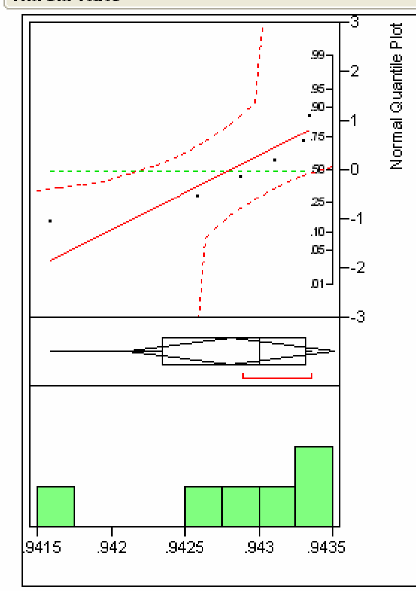
93|0 represents 0.930

Figure 324. Stem and Leaf and Normal Quantile Plot for Treatment 38

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94336
99.5%		0.94336
97.5%		0.94336
90.0%		0.94336
75.0%	quartile	0.94332
50.0%	median	0.94301
25.0%	quartile	0.94235
10.0%		0.94159
2.5%		0.94159
0.5%		0.94159
0.0%	minimum	0.94159

Moments

Mean	0.9428126
Std Dev	0.0006602
Std Err Mean	0.0002695
upper 95% Mean	0.9435054
lower 95% Mean	0.9421198
N	6

Stem and Leaf

Stem	Leaf	Count
9433	16	2
9432		
9431	3	1
9430		
9429		
9428	9	1
9427		
9426	0	1
9425		
9424		
9423		
9422		
9421		
9420		
9419		
9418		
9417		
9416		
9415	9	1

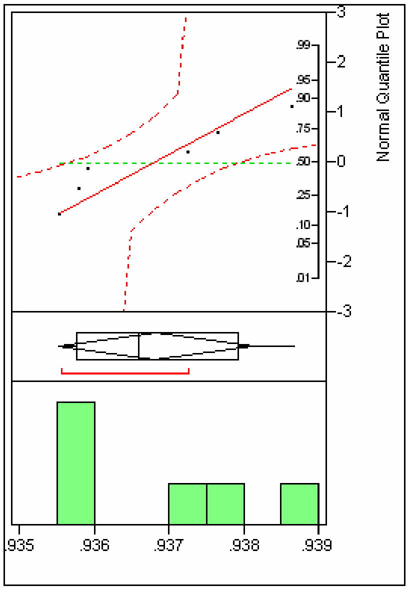
9415|9 represents 0.94159

Figure 325. Stem and Leaf and Normal Quantile Plot for Treatment 39

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.93867
99.5%		0.93867
97.5%		0.93867
90.0%		0.93867
75.0%	quartile	0.93793
50.0%	median	0.93660
25.0%	quartile	0.93576
10.0%		0.93556
2.5%		0.93556
0.5%		0.93556
0.0%	minimum	0.93556

Moments

Mean	0.9368239
Std Dev	0.0012421
Std Err Mean	0.0005071
upper 95% Mean	0.9381274
lower 95% Mean	0.9355205
N	6

Stem and Leaf

Stem	Leaf	Count
938	7	1
938		
937	7	1
937	3	1
936		
936		
935	689	3

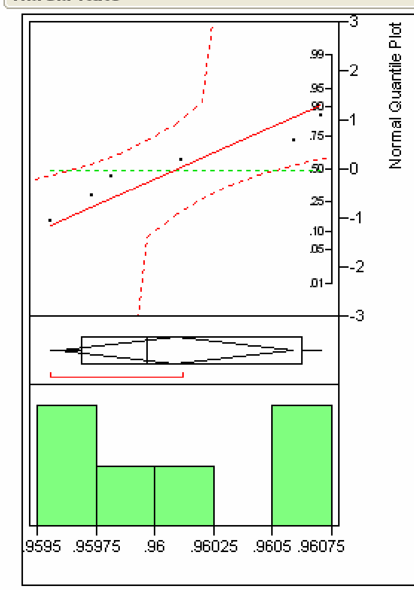
935|6 represents 0.9356

Figure 326. Stem and Leaf and Normal Quantile Plot for Treatment 40

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.96071
99.5%		0.96071
97.5%		0.96071
90.0%		0.96071
75.0%	quartile	0.96062
50.0%	median	0.95997
25.0%	quartile	0.95969
10.0%		0.95956
2.5%		0.95956
0.5%		0.95956
0.0%	minimum	0.95956

Moments

Mean	0.9600886
Std Dev	0.0004735
Std Err Mean	0.0001933
upper 95% Mean	0.9605855
lower 95% Mean	0.9595917
N	6

Stem and Leaf

Stem	Leaf	Count
9607	1	1
9606		
9605	9	1
9604		
9603		
9602		
9601	2	1
9600		
9599		
9598	2	1
9597	3	1
9596		
9595	6	1

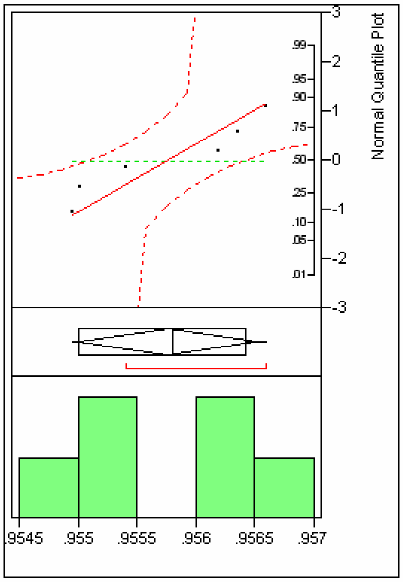
9595|6 represents 0.95956

Figure 327. Stem and Leaf and Normal Quantile Plot for Treatment 41

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95660
99.5%		0.95660
97.5%		0.95660
90.0%		0.95660
75.0%	quartile	0.95642
50.0%	median	0.95581
25.0%	quartile	0.95500
10.0%		0.95496
2.5%		0.95496
0.5%		0.95496
0.0%	minimum	0.95496

Moments

Mean	0.9557582
Std Dev	0.0007187
Std Err Mean	0.0002934
upper 95% Mean	0.9565125
lower 95% Mean	0.9550039
N	6

Stem and Leaf

Stem	Leaf	Count
9566	0	1
9565		
9564		
9563	7	1
9562	0	1
9561		
9560		
9559		
9558		
9557		
9556		
9555		
9554	1	1
9553		
9552		
9551		
9550	2	1
9549	6	1

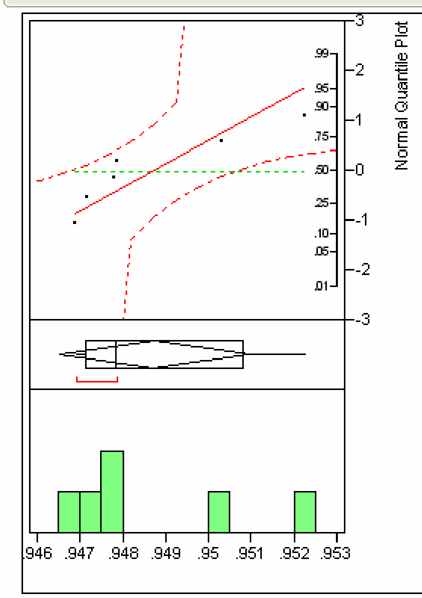
9549|6 represents 0.95496

Figure 328. Stem and Leaf and Normal Quantile Plot for Treatment 42

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.95227
99.5%		0.95227
97.5%		0.95227
90.0%		0.95227
75.0%	quartile	0.95082
50.0%	median	0.94785
25.0%	quartile	0.94712
10.0%		0.94691
2.5%		0.94691
0.5%		0.94691
0.0%	minimum	0.94691

Moments

Mean	0.948734
Std Dev	0.0021147
Std Err Mean	0.0008633
upper 95% Mean	0.9509533
lower 95% Mean	0.9465147
N	6

Stem and Leaf

Stem	Leaf	Count
952	3	1
951		
951		
950		
950	3	1
949		
949		
948		
948		
947	89	2
947	2	1
946	9	1

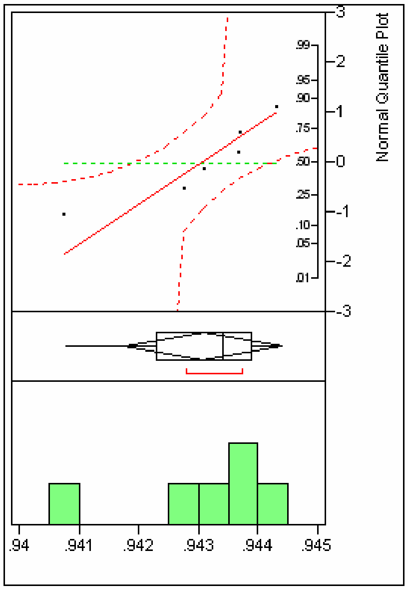
946|9 represents 0.9469

Figure 329. Stem and Leaf and Normal Quantile Plot for Treatment 43

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.94434
99.5%		0.94434
97.5%		0.94434
90.0%		0.94434
75.0%	quartile	0.94389
50.0%	median	0.94341
25.0%	quartile	0.94230
10.0%		0.94078
2.5%		0.94078
0.5%		0.94078
0.0%	minimum	0.94078

Moments

Mean	0.943081
Std Dev	0.0012464
Std Err Mean	0.0005088
upper 95% Mean	0.944389
lower 95% Mean	0.9417729
N	6

Stem and Leaf

Stem	Leaf	Count
944	3	1
943	77	2
943	1	1
942	8	1
942		
941		
941		
940	8	1

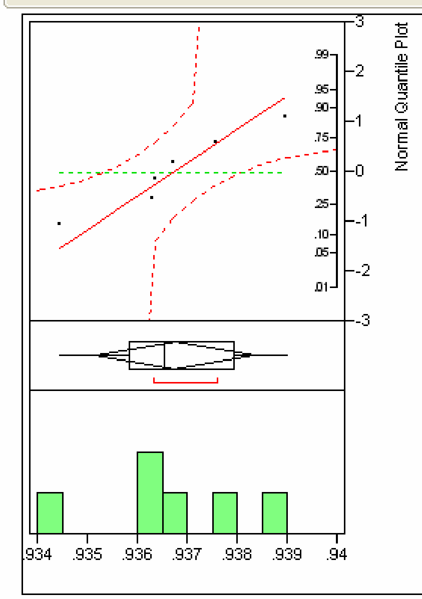
940|8 represents 0.9408

Figure 330. Stem and Leaf and Normal Quantile Plot for Treatment 44

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

NMCM Rate



Quantiles

100.0%	maximum	0.93900
99.5%		0.93900
97.5%		0.93900
90.0%		0.93900
75.0%	quartile	0.93795
50.0%	median	0.93656
25.0%	quartile	0.93586
10.0%		0.93446
2.5%		0.93446
0.5%		0.93446
0.0%	minimum	0.93446

Moments

Mean	0.9367509
Std Dev	0.0015068
Std Err Mean	0.0006151
upper 95% Mean	0.9383321
lower 95% Mean	0.9351696
N	6

Stem and Leaf

Stem	Leaf	Count
939	0	1
938		
938		
937	6	1
937		
936	8	1
936	34	2
935		
935		
934	5	1

934|5 represents 0.9345

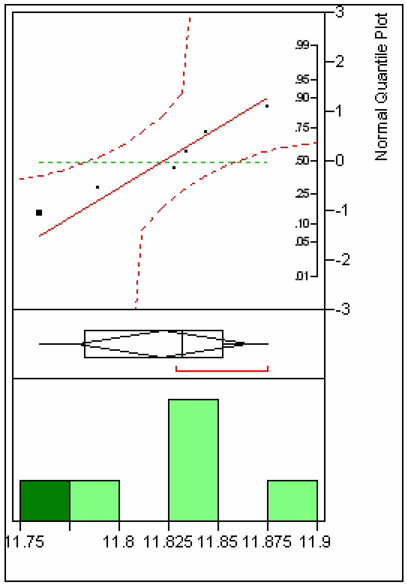
Figure 331. Stem and Leaf and Normal Quantile Plot for Treatment 45

Output Variable AWM

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

AWM



Quantiles

100.0%	maximum	11.875
99.5%		11.875
97.5%		11.875
90.0%		11.875
75.0%	quartile	11.852
50.0%	median	11.832
25.0%	quartile	11.782
10.0%		11.760
2.5%		11.760
0.5%		11.760
0.0%	minimum	11.760

Moments

Mean	11.822087
Std Dev	0.0410953
Std Err Mean	0.0167771
upper 95% Mean	11.865214
lower 95% Mean	11.77896
N	6

Stem and Leaf

Stem	Leaf	Count
1187	5	1
1186		
1185		
1184	5	1
1183	4	1
1182	9	1
1181		
1180		
1179	0	1
1178		
1177		
1176	0	1

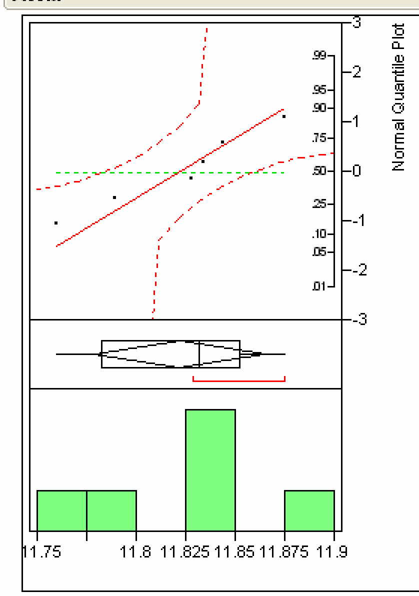
1176|0 represents 11.760

Figure 332. Stem and Leaf and Normal Quantile Plot for Treatment 1

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

AWM



Quantiles

100.0%	maximum	11.875
99.5%		11.875
97.5%		11.875
90.0%		11.875
75.0%	quartile	11.852
50.0%	median	11.832
25.0%	quartile	11.782
10.0%		11.760
2.5%		11.760
0.5%		11.760
0.0%	minimum	11.760

Moments

Mean	11.822087
Std Dev	0.0410953
Std Err Mean	0.0167771
upper 95% Mean	11.865214
lower 95% Mean	11.77896
N	6

Stem and Leaf

Stem	Leaf	Count
1187	5	1
1186		
1185		
1184	5	1
1183	4	1
1182	9	1
1181		
1180		
1179	0	1
1178		
1177		
1176	0	1

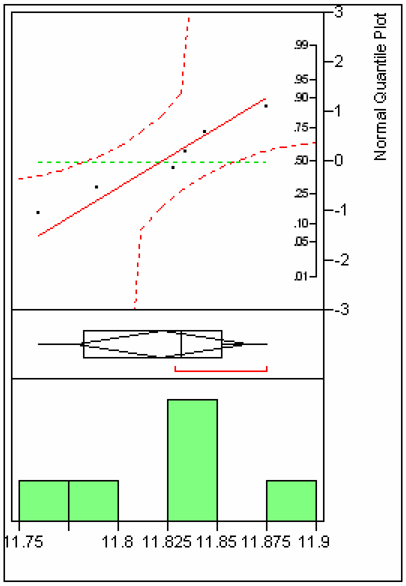
1176|0 represents 11.760

Figure 333. Stem and Leaf and Normal Quantile Plot for Treatment 2

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=3_100%

Distributions

AWM



Quantiles

100.0%	maximum	11.875
99.5%		11.875
97.5%		11.875
90.0%		11.875
75.0%	quartile	11.852
50.0%	median	11.832
25.0%	quartile	11.782
10.0%		11.760
2.5%		11.760
0.5%		11.760
0.0%	minimum	11.760

Moments

Mean	11.822087
Std Dev	0.0410953
Std Err Mean	0.0167771
upper 95% Mean	11.865214
lower 95% Mean	11.77896
N	6

Stem and Leaf

Stem	Leaf	Count
1187	5	1
1186		
1185		
1184	5	1
1183	4	1
1182	9	1
1181		
1180		
1179	0	1
1178		
1177		
1176	0	1

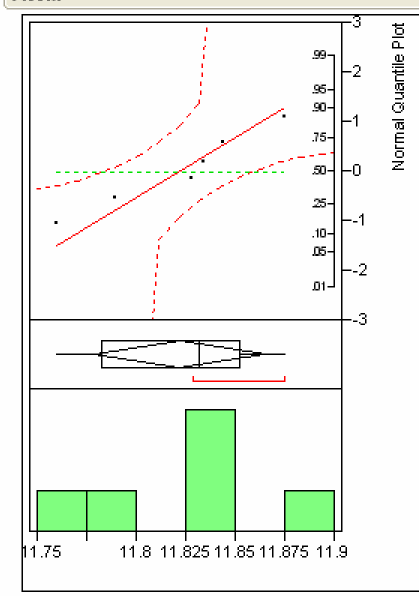
1176|0 represents 11.760

Figure 334. Stem and Leaf and Normal Quantile Plot for Treatment 3

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

AWM



Quantiles

100.0%	maximum	11.875
99.5%		11.875
97.5%		11.875
90.0%		11.875
75.0%	quartile	11.852
50.0%	median	11.832
25.0%	quartile	11.782
10.0%		11.760
2.5%		11.760
0.5%		11.760
0.0%	minimum	11.760

Moments

Mean	11.822087
Std Dev	0.0410953
Std Err Mean	0.0167771
upper 95% Mean	11.865214
lower 95% Mean	11.77896
N	6

Stem and Leaf

Stem	Leaf	Count
1187	5	1
1186		
1185		
1184	5	1
1183	4	1
1182	9	1
1181		
1180		
1179	0	1
1178		
1177		
1176	0	1

1176|0 represents 11.760

Figure 335. Stem and Leaf and Normal Quantile Plot for Treatment 4

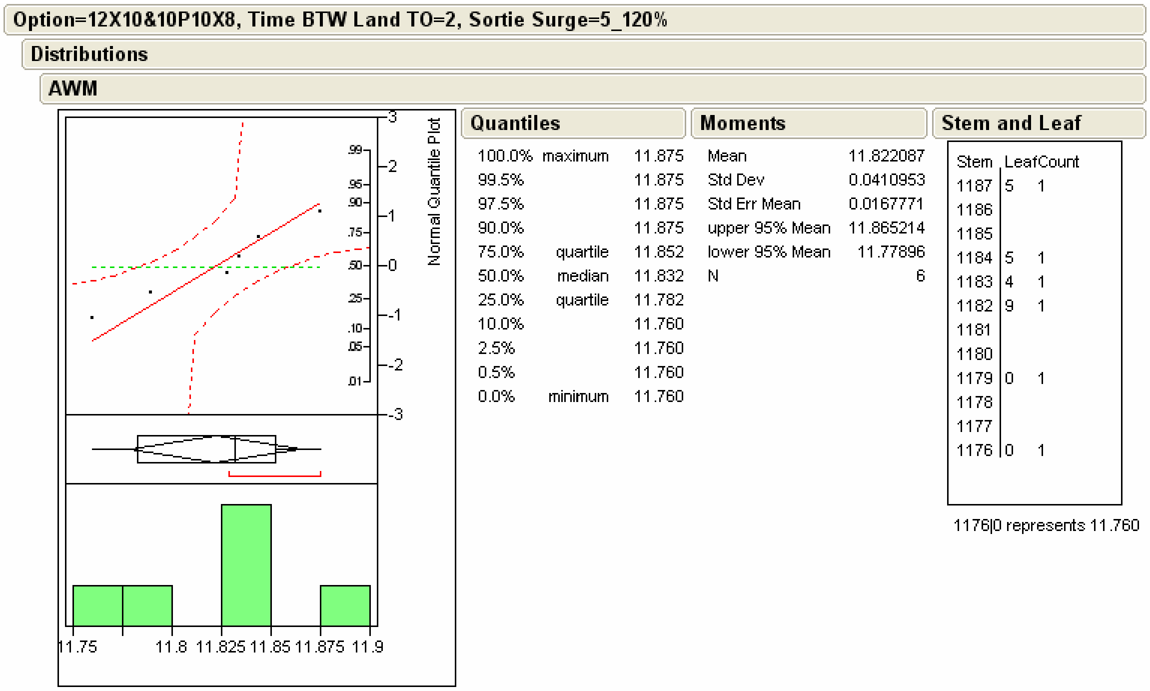


Figure 336. Stem and Leaf and Normal Quantile Plot for Treatment 5

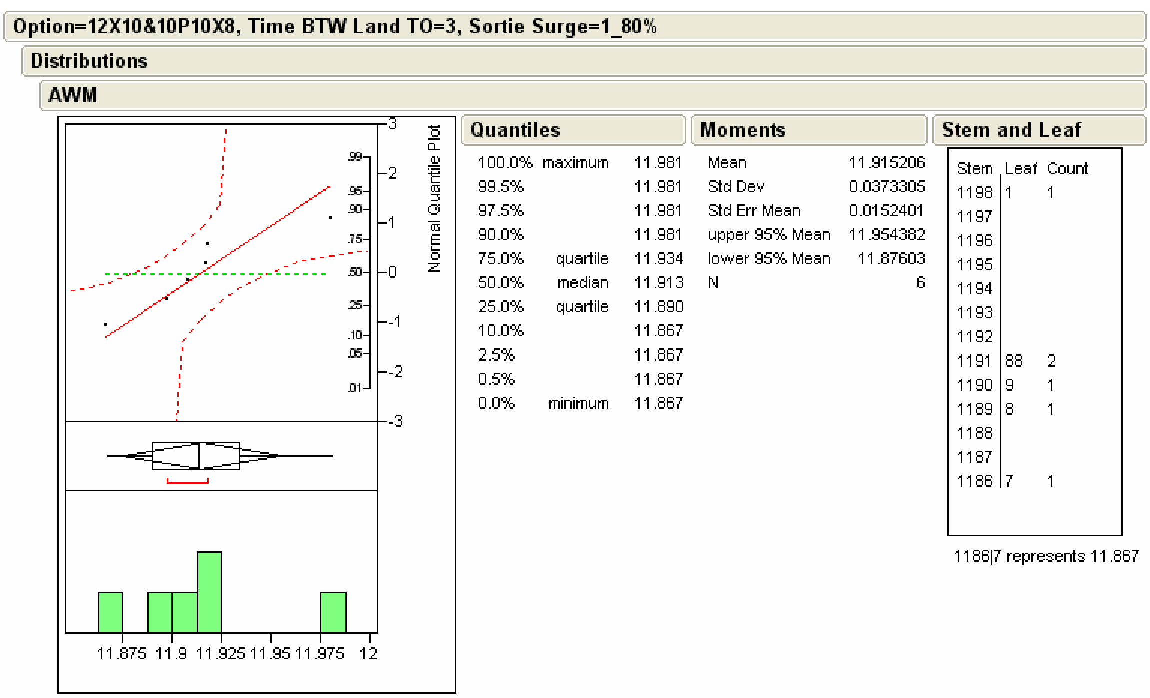
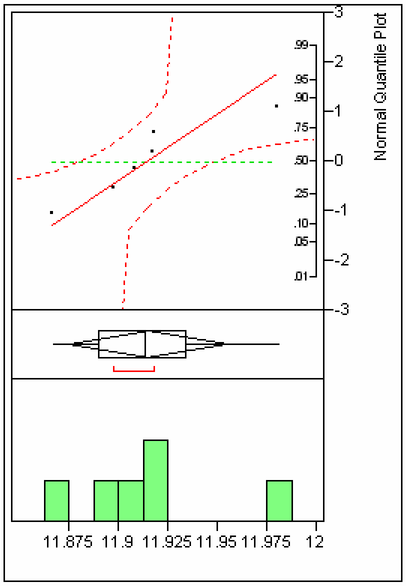


Figure 337. Stem and Leaf and Normal Quantile Plot for Treatment 6

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

AWM



Quantiles

100.0%	maximum	11.981
99.5%		11.981
97.5%		11.981
90.0%		11.981
75.0%	quartile	11.934
50.0%	median	11.913
25.0%	quartile	11.890
10.0%		11.867
2.5%		11.867
0.5%		11.867
0.0%	minimum	11.867

Moments

Mean	11.915206
Std Dev	0.0373305
Std Err Mean	0.0152401
upper 95% Mean	11.954382
lower 95% Mean	11.87603
N	6

Stem and Leaf

Stem	Leaf	Count
1198	1	1
1197		
1196		
1195		
1194		
1193		
1192		
1191	88	2
1190	9	1
1189	8	1
1188		
1187		
1186	7	1

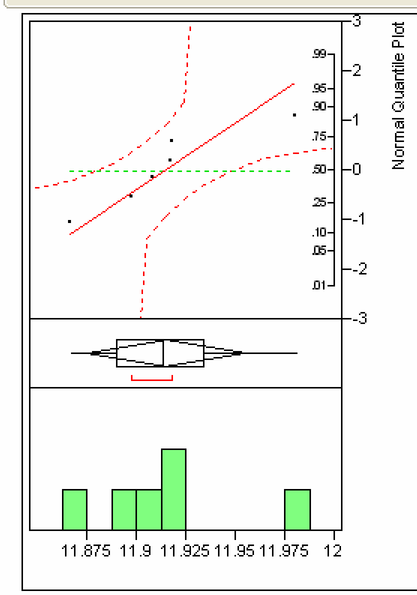
1186|7 represents 11.867

Figure 338. Stem and Leaf and Normal Quantile Plot for Treatment 7

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

AWM



Quantiles

100.0%	maximum	11.981
99.5%		11.981
97.5%		11.981
90.0%		11.981
75.0%	quartile	11.934
50.0%	median	11.913
25.0%	quartile	11.890
10.0%		11.867
2.5%		11.867
0.5%		11.867
0.0%	minimum	11.867

Moments

Mean	11.915206
Std Dev	0.0373305
Std Err Mean	0.0152401
upper 95% Mean	11.954382
lower 95% Mean	11.87603
N	6

Stem and Leaf

Stem	Leaf	Count
1198	1	1
1197		
1196		
1195		
1194		
1193		
1192		
1191	88	2
1190	9	1
1189	8	1
1188		
1187		
1186	7	1

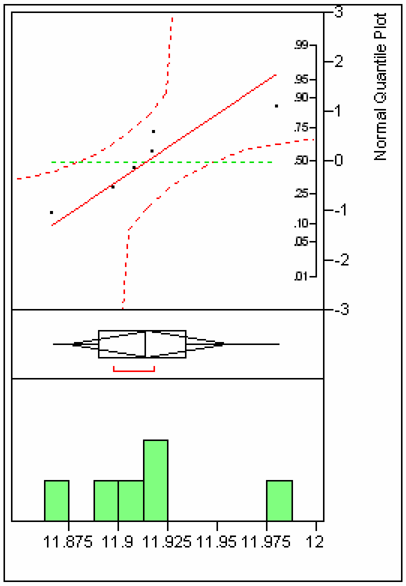
1186|7 represents 11.867

Figure 339. Stem and Leaf and Normal Quantile Plot for Treatment 8

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

AWM



Quantiles

100.0%	maximum	11.981
99.5%		11.981
97.5%		11.981
90.0%		11.981
75.0%	quartile	11.934
50.0%	median	11.913
25.0%	quartile	11.890
10.0%		11.867
2.5%		11.867
0.5%		11.867
0.0%	minimum	11.867

Moments

Mean	11.915206
Std Dev	0.0373305
Std Err Mean	0.0152401
upper 95% Mean	11.954382
lower 95% Mean	11.87603
N	6

Stem and Leaf

Stem	Leaf	Count
1198	1	1
1197		
1196		
1195		
1194		
1193		
1192		
1191	88	2
1190	9	1
1189	8	1
1188		
1187		
1186	7	1

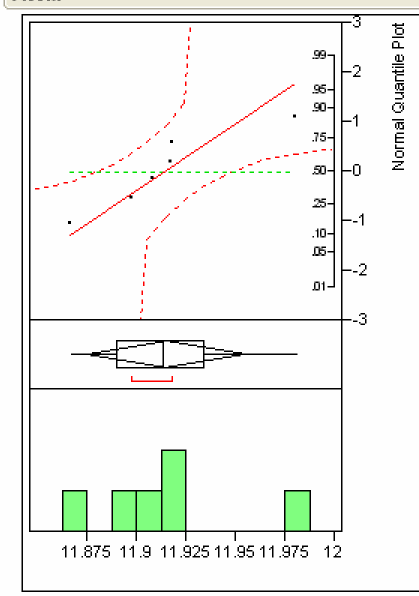
1186|7 represents 11.867

Figure 340. Stem and Leaf and Normal Quantile Plot for Treatment 9

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

AWM



Quantiles

100.0%	maximum	11.981
99.5%		11.981
97.5%		11.981
90.0%		11.981
75.0%	quartile	11.934
50.0%	median	11.913
25.0%	quartile	11.890
10.0%		11.867
2.5%		11.867
0.5%		11.867
0.0%	minimum	11.867

Moments

Mean	11.915206
Std Dev	0.0373305
Std Err Mean	0.0152401
upper 95% Mean	11.954382
lower 95% Mean	11.87603
N	6

Stem and Leaf

Stem	Leaf	Count
1198	1	1
1197		
1196		
1195		
1194		
1193		
1192		
1191	88	2
1190	9	1
1189	8	1
1188		
1187		
1186	7	1

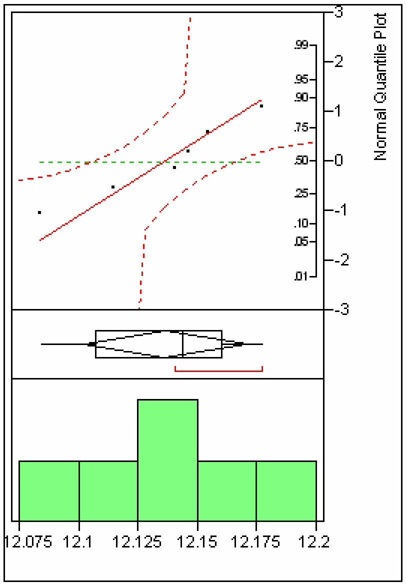
1186|7 represents 11.867

Figure 341. Stem and Leaf and Normal Quantile Plot for Treatment 10

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

AWM



Quantiles

100.0%	maximum	12.177
99.5%		12.177
97.5%		12.177
90.0%		12.177
75.0%	quartile	12.160
50.0%	median	12.144
25.0%	quartile	12.107
10.0%		12.084
2.5%		12.084
0.5%		12.084
0.0%	minimum	12.084

Moments

Mean	12.136498
Std Dev	0.0326126
Std Err Mean	0.013314
upper 95% Mean	12.170722
lower 95% Mean	12.102273
N	6

Stem and Leaf

Stem	Leaf	Count
1217	7	1
1216		
1215	5	1
1214	17	2
1213		
1212		
1211	5	1
1210		
1209		
1208	4	1

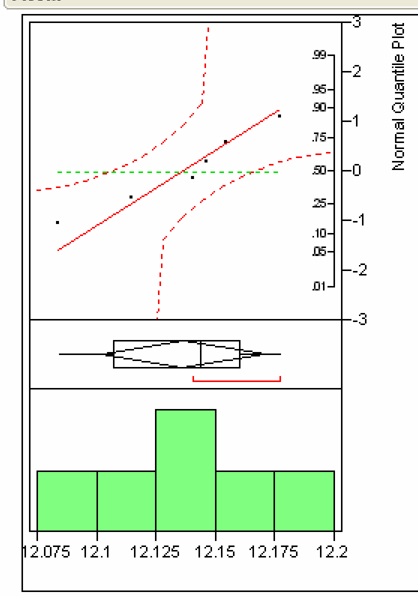
1208|4 represents 12.084

Figure 342. Stem and Leaf and Normal Quantile Plot for Treatment 11

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

AWM



Quantiles

100.0%	maximum	12.177
99.5%		12.177
97.5%		12.177
90.0%		12.177
75.0%	quartile	12.160
50.0%	median	12.144
25.0%	quartile	12.107
10.0%		12.084
2.5%		12.084
0.5%		12.084
0.0%	minimum	12.084

Moments

Mean	12.136498
Std Dev	0.0326126
Std Err Mean	0.013314
upper 95% Mean	12.170722
lower 95% Mean	12.102273
N	6

Stem and Leaf

Stem	Leaf	Count
1217	7	1
1216		
1215	5	1
1214	17	2
1213		
1212		
1211	5	1
1210		
1209		
1208	4	1

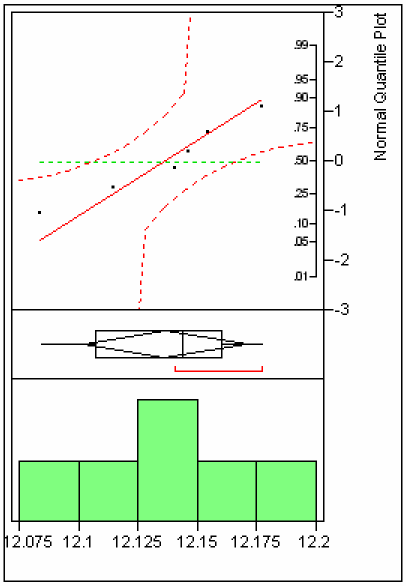
1208|4 represents 12.084

Figure 343. Stem and Leaf and Normal Quantile Plot for Treatment 12

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

AWM



Quantiles

100.0%	maximum	12.177
99.5%		12.177
97.5%		12.177
90.0%		12.177
75.0%	quartile	12.160
50.0%	median	12.144
25.0%	quartile	12.107
10.0%		12.084
2.5%		12.084
0.5%		12.084
0.0%	minimum	12.084

Moments

Mean	12.136498
Std Dev	0.0326126
Std Err Mean	0.013314
upper 95% Mean	12.170722
lower 95% Mean	12.102273
N	6

Stem and Leaf

Stem	Leaf	Count
1217	7	1
1216		
1215	5	1
1214	17	2
1213		
1212		
1211	5	1
1210		
1209		
1208	4	1

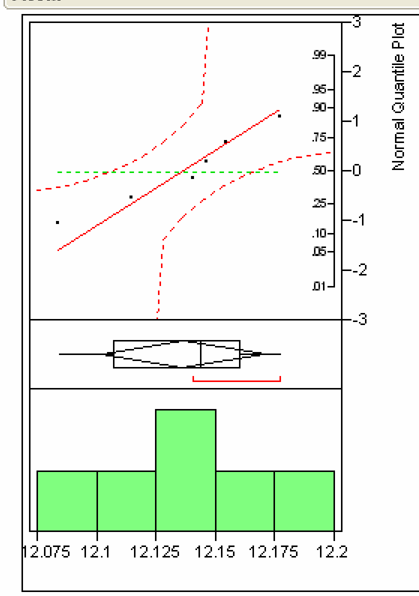
1208|4 represents 12.084

Figure 344. Stem and Leaf and Normal Quantile Plot for Treatment 13

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

AWM



Quantiles

100.0%	maximum	12.177
99.5%		12.177
97.5%		12.177
90.0%		12.177
75.0%	quartile	12.160
50.0%	median	12.144
25.0%	quartile	12.107
10.0%		12.084
2.5%		12.084
0.5%		12.084
0.0%	minimum	12.084

Moments

Mean	12.136498
Std Dev	0.0326126
Std Err Mean	0.013314
upper 95% Mean	12.170722
lower 95% Mean	12.102273
N	6

Stem and Leaf

Stem	Leaf	Count
1217	7	1
1216		
1215	5	1
1214	17	2
1213		
1212		
1211	5	1
1210		
1209		
1208	4	1

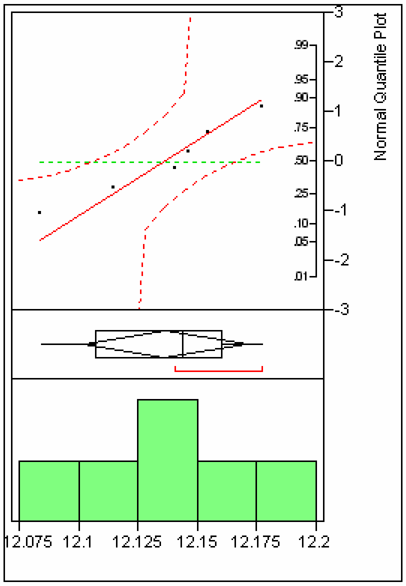
1208|4 represents 12.084

Figure 345. Stem and Leaf and Normal Quantile Plot for Treatment 14

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

AWM



Quantiles

100.0%	maximum	12.177
99.5%		12.177
97.5%		12.177
90.0%		12.177
75.0%	quartile	12.160
50.0%	median	12.144
25.0%	quartile	12.107
10.0%		12.084
2.5%		12.084
0.5%		12.084
0.0%	minimum	12.084

Moments

Mean	12.136498
Std Dev	0.0326126
Std Err Mean	0.013314
upper 95% Mean	12.170722
lower 95% Mean	12.102273
N	6

Stem and Leaf

Stem	Leaf	Count
1217	7	1
1216		
1215	5	1
1214	17	2
1213		
1212		
1211	5	1
1210		
1209		
1208	4	1

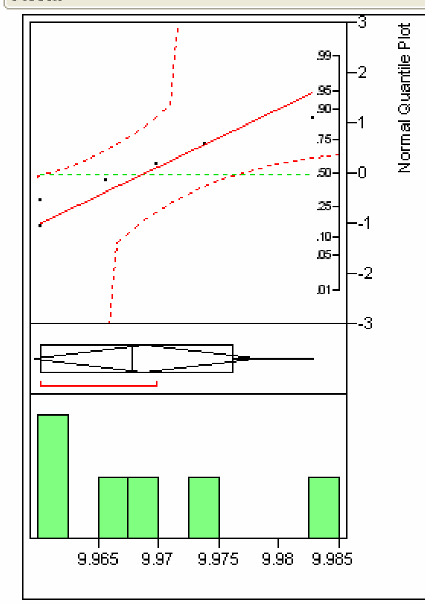
1208|4 represents 12.084

Figure 346. Stem and Leaf and Normal Quantile Plot for Treatment 15

Option=3WMF, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

AWM



Quantiles

100.0%	maximum	9.9829
99.5%		9.9829
97.5%		9.9829
90.0%		9.9829
75.0%	quartile	9.9762
50.0%	median	9.9678
25.0%	quartile	9.9603
10.0%		9.9603
2.5%		9.9603
0.5%		9.9603
0.0%	minimum	9.9603

Moments

Mean	9.9688434
Std Dev	0.0087225
Std Err Mean	0.003561
upper 95% Mean	9.9779972
lower 95% Mean	9.9596897
N	6

Stem and Leaf

Stem	Leaf	Count
998	3	1
998		
997		
997		
997	4	1
997		
997	0	1
996		
996	6	1
996		
996		
996	00	2

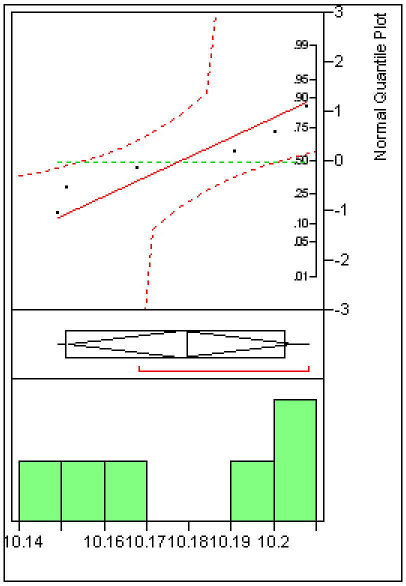
996|0 represents 9.960

Figure 347. Stem and Leaf and Normal Quantile Plot for Treatment 16

Option=3WMF, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

AWM



Quantiles

100.0%	maximum	10.208
99.5%		10.208
97.5%		10.208
90.0%		10.208
75.0%	quartile	10.203
50.0%	median	10.180
25.0%	quartile	10.151
10.0%		10.149
2.5%		10.149
0.5%		10.149
0.0%	minimum	10.149

Moments

Mean	10.178158
Std Dev	0.0254006
Std Err Mean	0.0103698
upper 95% Mean	10.204814
lower 95% Mean	10.151502
N	6

Stem and Leaf

Stem	Leaf	Count
1020	8	1
1020	1	1
1019		
1019	1	1
1018		
1018		
1017		
1017		
1016	8	1
1016		
1015		
1015	1	1
1014	9	1

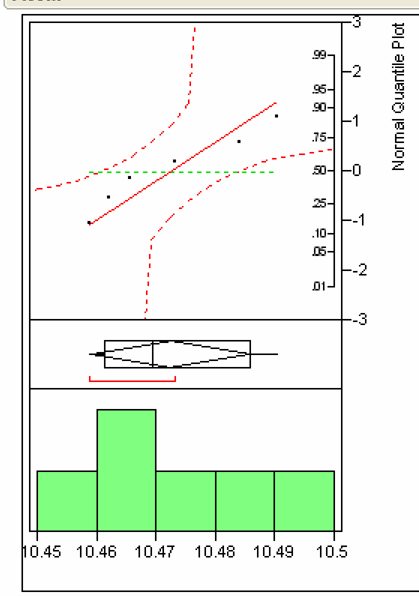
1014|9 represents 10.149

Figure 348. Stem and Leaf and Normal Quantile Plot for Treatment 17

Option=3WMF, Time BTW Land TO=2, Sortie Surge=3_100%

Distributions

AWM



Quantiles

100.0%	maximum	10.490
99.5%		10.490
97.5%		10.490
90.0%		10.490
75.0%	quartile	10.486
50.0%	median	10.470
25.0%	quartile	10.461
10.0%		10.459
2.5%		10.459
0.5%		10.459
0.0%	minimum	10.459

Moments

Mean	10.472492
Std Dev	0.0125994
Std Err Mean	0.0051437
upper 95% Mean	10.485714
lower 95% Mean	10.45927
N	6

Stem and Leaf

Stem	Leaf	Count
1049	0	1
1048		
1048	4	1
1047		
1047	3	1
1046	6	1
1046	2	1
1045	9	1

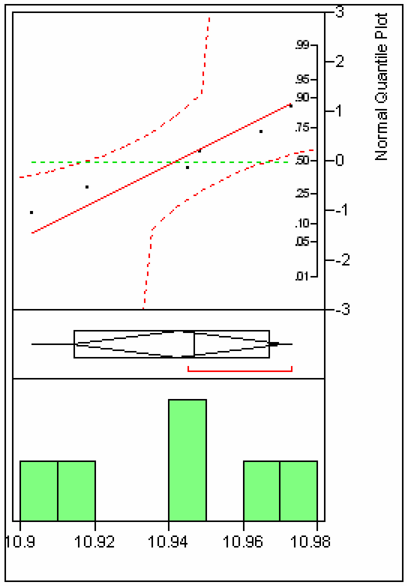
1045|9 represents 10.459

Figure 349. Stem and Leaf and Normal Quantile Plot for Treatment 18

Option=3WMF, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

AWM



Quantiles

100.0%	maximum	10.973
99.5%		10.973
97.5%		10.973
90.0%		10.973
75.0%	quartile	10.967
50.0%	median	10.947
25.0%	quartile	10.915
10.0%		10.903
2.5%		10.903
0.5%		10.903
0.0%	minimum	10.903

Moments

Mean	10.942364
Std Dev	0.0268538
Std Err Mean	0.010963
upper 95% Mean	10.970545
lower 95% Mean	10.914183
N	6

Stem and Leaf

Stem	Leaf	Count
1097	3	1
1096	5	1
1096		
1095		
1095		
1094	59	2
1094		
1093		
1093		
1092		
1092		
1091	8	1
1091		
1090		
1090	3	1

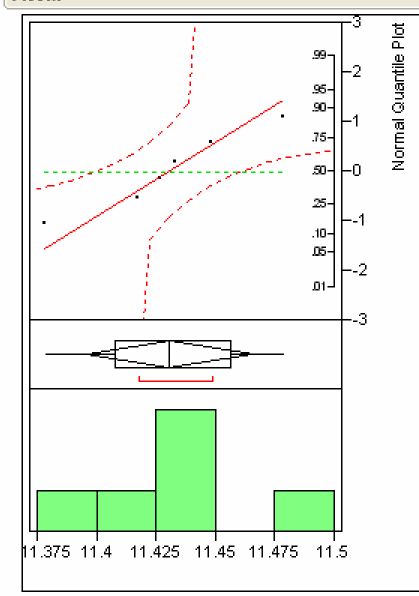
1090|3 represents 10.903

Figure 350. Stem and Leaf and Normal Quantile Plot for Treatment 19

Option=3WMF, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

AWM



Quantiles

100.0%	maximum	11.479
99.5%		11.479
97.5%		11.479
90.0%		11.479
75.0%	quartile	11.456
50.0%	median	11.430
25.0%	quartile	11.408
10.0%		11.379
2.5%		11.379
0.5%		11.379
0.0%	minimum	11.379

Moments

Mean	11.430834
Std Dev	0.0332165
Std Err Mean	0.0135606
upper 95% Mean	11.465692
lower 95% Mean	11.395975
N	6

Stem and Leaf

Stem	Leaf	Count
1147	9	1
1146		
1145		
1144	9	1
1143	4	1
1142	7	1
1141	8	1
1140		
1139		
1138		
1137	9	1

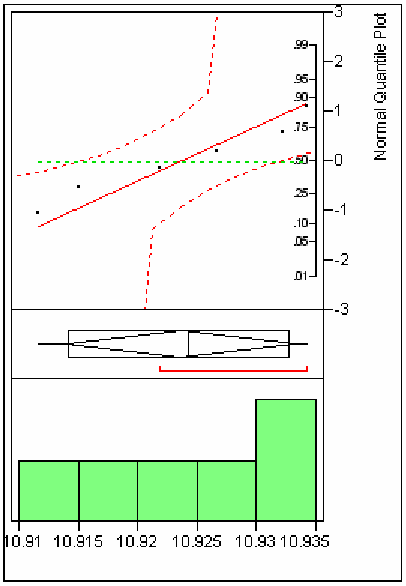
1137|9 represents 11.379

Figure 351. Stem and Leaf and Normal Quantile Plot for Treatment 20

Option=3WMF, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

AWM



Quantiles

100.0%	maximum	10.934
99.5%		10.934
97.5%		10.934
90.0%		10.934
75.0%	quartile	10.933
50.0%	median	10.924
25.0%	quartile	10.914
10.0%		10.912
2.5%		10.912
0.5%		10.912
0.0%	minimum	10.912

Moments

Mean	10.923646
Std Dev	0.0091325
Std Err Mean	0.0037283
upper 95% Mean	10.93323
lower 95% Mean	10.914062
N	6

Stem and Leaf

Stem	Leaf	Count
1093	4	1
1093	2	1
1093		
1092		
1092	7	1
1092		
1092	2	1
1092		
1091		
1091		
1091	5	1
1091	2	1

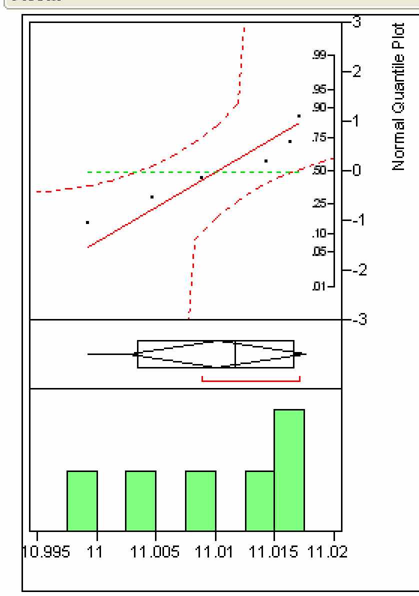
1091|2 represents 10.912

Figure 352. Stem and Leaf and Normal Quantile Plot for Treatment 21

Option=3WMF, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

AWM



Quantiles

100.0%	maximum	11.017
99.5%		11.017
97.5%		11.017
90.0%		11.017
75.0%	quartile	11.017
50.0%	median	11.012
25.0%	quartile	11.003
10.0%		10.999
2.5%		10.999
0.5%		10.999
0.0%	minimum	10.999

Moments

Mean	11.010159
Std Dev	0.0071245
Std Err Mean	0.0029086
upper 95% Mean	11.017635
lower 95% Mean	11.002682
N	6

Stem and Leaf

Stem	Leaf	Count
1101	67	2
1101	4	1
1101		
1101		
1100	9	1
1100		
1100	5	1
1100		
1100		
1099	9	1

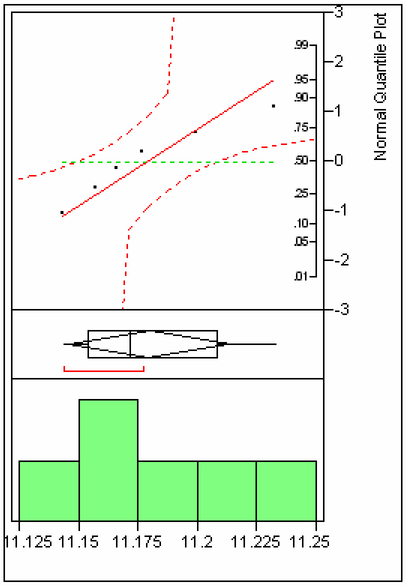
1099|9 represents 10.999

Figure 353. Stem and Leaf and Normal Quantile Plot for Treatment 22

Option=3WMF, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

AWM



Quantiles

100.0%	maximum	11.233
99.5%		11.233
97.5%		11.233
90.0%		11.233
75.0%	quartile	11.208
50.0%	median	11.172
25.0%	quartile	11.154
10.0%		11.144
2.5%		11.144
0.5%		11.144
0.0%	minimum	11.144

Moments

Mean	11.179644
Std Dev	0.0322744
Std Err Mean	0.013176
upper 95% Mean	11.213514
lower 95% Mean	11.145775
N	6

Stem and Leaf

Stem	Leaf	Count
1123	3	1
1122		
1121		
1120	0	1
1119		
1118		
1117	7	1
1116	6	1
1115	7	1
1114	4	1

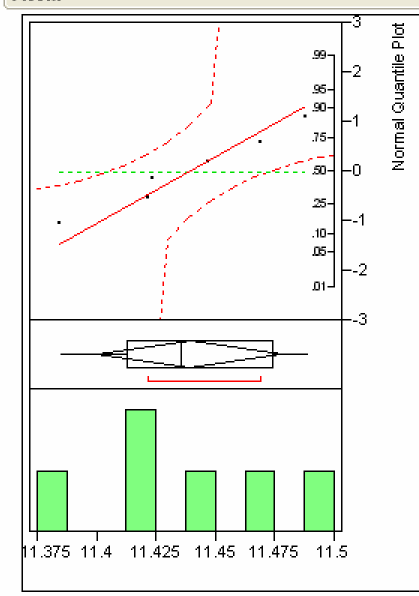
1114|4 represents 11.144

Figure 354. Stem and Leaf and Normal Quantile Plot for Treatment 23

Option=3WMF, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

AWM



Quantiles

100.0%	maximum	11.488
99.5%		11.488
97.5%		11.488
90.0%		11.488
75.0%	quartile	11.474
50.0%	median	11.436
25.0%	quartile	11.413
10.0%		11.385
2.5%		11.385
0.5%		11.385
0.0%	minimum	11.385

Moments

Mean	11.439276
Std Dev	0.0370354
Std Err Mean	0.0151196
upper 95% Mean	11.478143
lower 95% Mean	11.40041
N	6

Stem and Leaf

Stem	Leaf	Count
1148	8	1
1147		
1146	9	1
1145		
1144	7	1
1143		
1142	24	2
1141		
1140		
1139		
1138	5	1

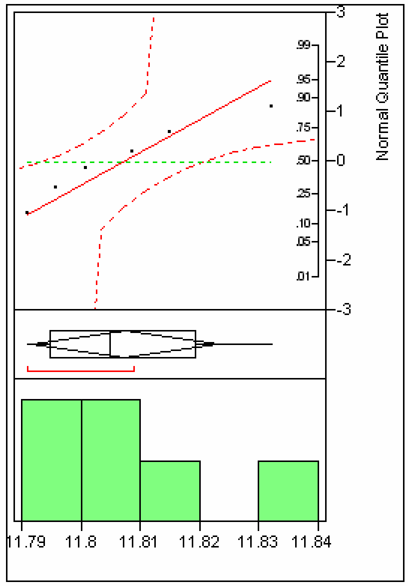
1138|5 represents 11.385

Figure 355. Stem and Leaf and Normal Quantile Plot for Treatment 24

Option=3WMF, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

AWM



Quantiles

100.0%	maximum	11.832
99.5%		11.832
97.5%		11.832
90.0%		11.832
75.0%	quartile	11.819
50.0%	median	11.805
25.0%	quartile	11.795
10.0%		11.791
2.5%		11.791
0.5%		11.791
0.0%	minimum	11.791

Moments

Mean	11.807351
Std Dev	0.0149364
Std Err Mean	0.0060978
upper 95% Mean	11.823026
lower 95% Mean	11.791677
N	6

Stem and Leaf

Stem	Leaf	Count
1183	2	1
1182		
1182		
1181	5	1
1181		
1180	9	1
1180	1	1
1179	6	1
1179	1	1

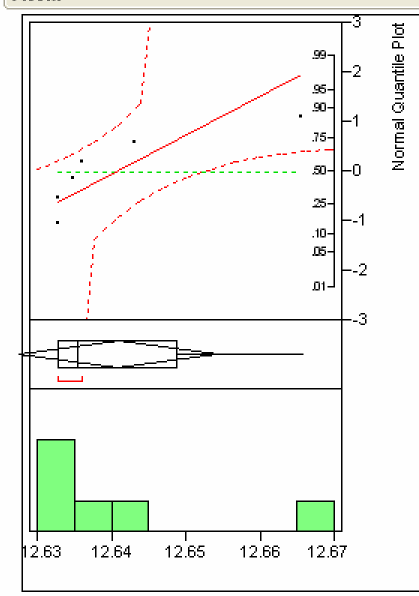
1179|1 represents 11.791

Figure 356. Stem and Leaf and Normal Quantile Plot for Treatment 25

Option=3WMF, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

AWM



Quantiles

100.0%	maximum	12.666
99.5%		12.666
97.5%		12.666
90.0%		12.666
75.0%	quartile	12.649
50.0%	median	12.636
25.0%	quartile	12.633
10.0%		12.633
2.5%		12.633
0.5%		12.633
0.0%	minimum	12.633

Moments

Mean	12.640951
Std Dev	0.012728
Std Err Mean	0.0051962
upper 95% Mean	12.654308
lower 95% Mean	12.627593
N	6

Stem and Leaf

Stem	Leaf	Count
1266	6	1
1266		
1265		
1265		
1264		
1264	3	1
1263	56	2
1263	33	2

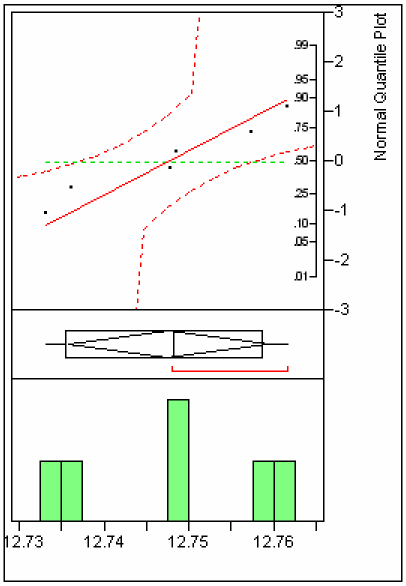
1263|3 represents 12.633

Figure 357. Stem and Leaf and Normal Quantile Plot for Treatment 26

Option=3WMF, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

AWM



Quantiles

100.0%	maximum	12.762
99.5%		12.762
97.5%		12.762
90.0%		12.762
75.0%	quartile	12.759
50.0%	median	12.748
25.0%	quartile	12.736
10.0%		12.733
2.5%		12.733
0.5%		12.733
0.0%	minimum	12.733

Moments

Mean	12.747549
Std Dev	0.0112329
Std Err Mean	0.0045858
upper 95% Mean	12.759338
lower 95% Mean	12.735761
N	6

Stem and Leaf

Stem	Leaf	Count
1276	2	1
1275	8	1
1275		
1274	89	2
1274		
1273	6	1
1273	3	1

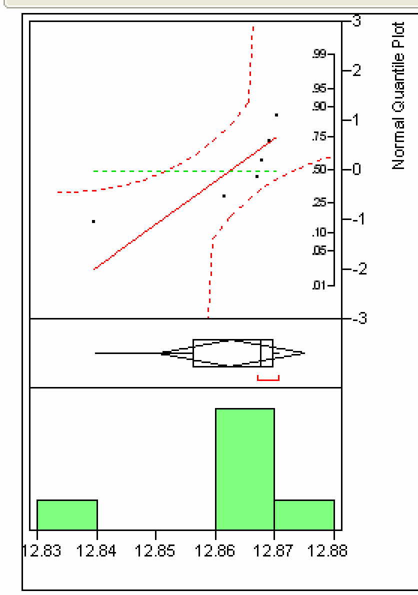
1273|3 represents 12.733

Figure 358. Stem and Leaf and Normal Quantile Plot for Treatment 27

Option=3WMF, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

AWM



Quantiles

100.0%	maximum	12.871
99.5%		12.871
97.5%		12.871
90.0%		12.871
75.0%	quartile	12.870
50.0%	median	12.868
25.0%	quartile	12.856
10.0%		12.840
2.5%		12.840
0.5%		12.840
0.0%	minimum	12.840

Moments

Mean	12.862701
Std Dev	0.011662
Std Err Mean	0.004761
upper 95% Mean	12.87494
lower 95% Mean	12.850463
N	6

Stem and Leaf

Stem	Leaf	Count
1287	1	1
1286	89	2
1286	7	1
1286		
1286	2	1
1286		
1285		
1285		
1285		
1285		
1285		
1284		
1284		
1284		
1284		
1284	0	1

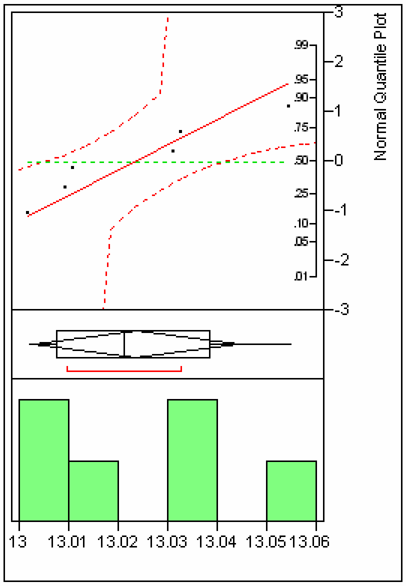
1284|0 represents 12.840

Figure 359. Stem and Leaf and Normal Quantile Plot for Treatment 28

Option=3WMF, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

AWM



Quantiles

100.0%	maximum	13.055
99.5%		13.055
97.5%		13.055
90.0%		13.055
75.0%	quartile	13.038
50.0%	median	13.021
25.0%	quartile	13.008
10.0%		13.002
2.5%		13.002
0.5%		13.002
0.0%	minimum	13.002

Moments

Mean	13.02363
Std Dev	0.0197083
Std Err Mean	0.0080459
upper 95% Mean	13.044312
lower 95% Mean	13.002947
N	6

Stem and Leaf

Stem	Leaf	Count
1305	5	1
1305		
1304		
1304		
1303		
1303	23	2
1302		
1302		
1301		
1301	01	2
1300		
1300	2	1

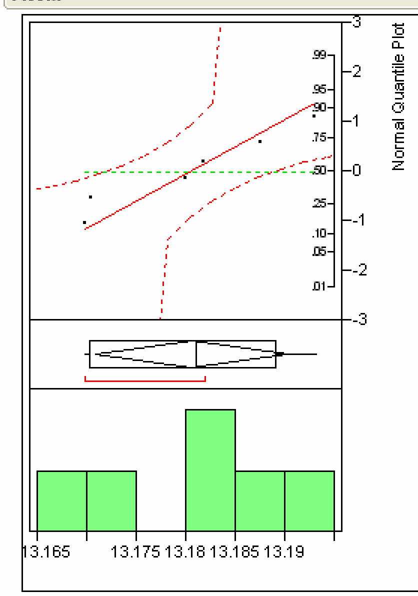
1300|2 represents 13.002

Figure 360. Stem and Leaf and Normal Quantile Plot for Treatment 29

Option=3WMF, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

AWM



Quantiles

100.0%	maximum	13.193
99.5%		13.193
97.5%		13.193
90.0%		13.193
75.0%	quartile	13.189
50.0%	median	13.181
25.0%	quartile	13.170
10.0%		13.170
2.5%		13.170
0.5%		13.170
0.0%	minimum	13.170

Moments

Mean	13.180552
Std Dev	0.0092288
Std Err Mean	0.0037676
upper 95% Mean	13.190237
lower 95% Mean	13.170867
N	6

Stem and Leaf

Stem	Leaf	Count
1319	3	1
1319		
1318	8	1
1318		
1318		
1318	2	1
1318	0	1
1317		
1317		
1317		
1317		
1317	01	2

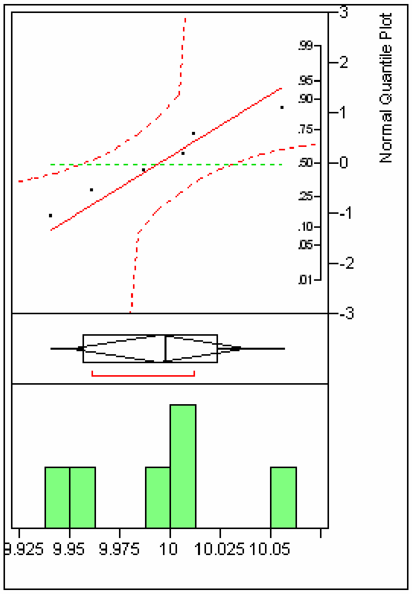
1317|0 represents 13.170

Figure 361. Stem and Leaf and Normal Quantile Plot for Treatment 30

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

AWM



Quantiles

100.0%	maximum	10.057
99.5%		10.057
97.5%		10.057
90.0%		10.057
75.0%	quartile	10.023
50.0%	median	9.998
25.0%	quartile	9.957
10.0%		9.941
2.5%		9.941
0.5%		9.941
0.0%	minimum	9.941

Moments

Mean	9.9945076
Std Dev	0.0408501
Std Err Mean	0.016677
upper 95% Mean	10.037377
lower 95% Mean	9.951638
N	6

Stem and Leaf

Stem	Leaf	Count
1005	7	1
1004		
1003		
1002		
1001	2	1
1000	8	1
999		
998	8	1
997		
996	2	1
995		
994	1	1

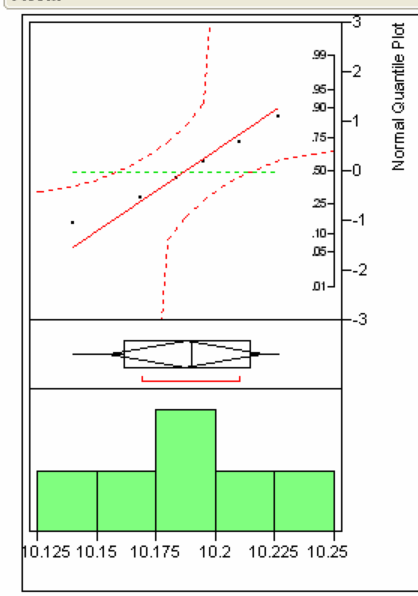
994|1 represents 9.941

Figure 362. Stem and Leaf and Normal Quantile Plot for Treatment 31

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

AWM



Quantiles

100.0%	maximum	10.227
99.5%		10.227
97.5%		10.227
90.0%		10.227
75.0%	quartile	10.214
50.0%	median	10.190
25.0%	quartile	10.162
10.0%		10.140
2.5%		10.140
0.5%		10.140
0.0%	minimum	10.140

Moments

Mean	10.187633
Std Dev	0.0306193
Std Err Mean	0.0125003
upper 95% Mean	10.219766
lower 95% Mean	10.1555
N	6

Stem and Leaf

Stem	Leaf	Count
1022	7	1
1022		
1021		
1021	0	1
1020		
1020		
1019	5	1
1019		
1018		
1018	4	1
1017		
1017		
1016	9	1
1016		
1015		
1015		
1014		
1014	0	1

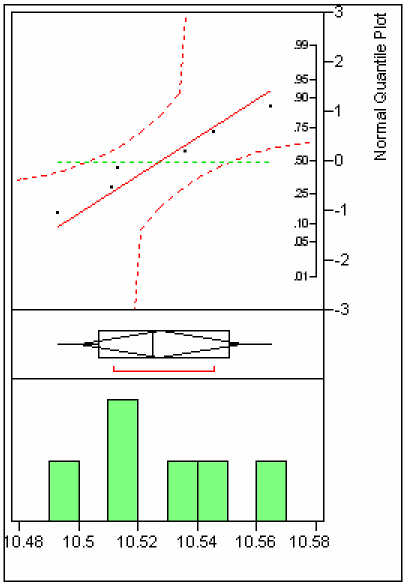
1014|0 represents 10.140

Figure 363. Stem and Leaf and Normal Quantile Plot for Treatment 32

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=3_100%

Distributions

AWM



Quantiles

100.0%	maximum	10.565
99.5%		10.565
97.5%		10.565
90.0%		10.565
75.0%	quartile	10.551
50.0%	median	10.525
25.0%	quartile	10.507
10.0%		10.493
2.5%		10.493
0.5%		10.493
0.0%	minimum	10.493

Moments

Mean	10.527623
Std Dev	0.026265
Std Err Mean	0.0107226
upper 95% Mean	10.555186
lower 95% Mean	10.500059
N	6

Stem and Leaf

Stem	Leaf	Count
1056	5	1
1056		
1055		
1055		
1054	6	1
1054		
1053	6	1
1053		
1052		
1052		
1051		
1051	24	2
1050		
1050		
1049		
1049	3	1

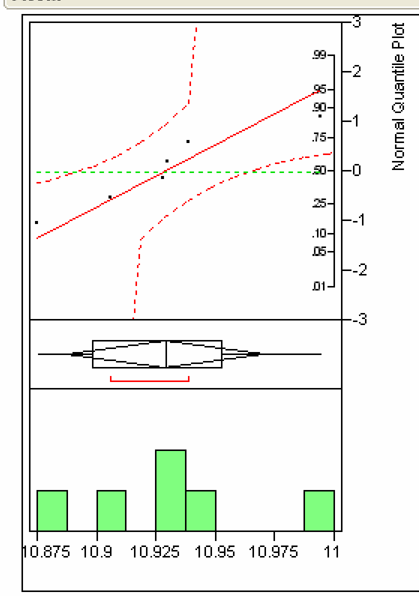
1049|3 represents 10.493

Figure 364. Stem and Leaf and Normal Quantile Plot for Treatment 33

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

AWM



Quantiles

100.0%	maximum	10.995
99.5%		10.995
97.5%		10.995
90.0%		10.995
75.0%	quartile	10.953
50.0%	median	10.929
25.0%	quartile	10.898
10.0%		10.875
2.5%		10.875
0.5%		10.875
0.0%	minimum	10.875

Moments

Mean	10.928897
Std Dev	0.0394884
Std Err Mean	0.0161211
upper 95% Mean	10.970338
lower 95% Mean	10.887457
N	6

Stem and Leaf

Stem	Leaf	Count
1099	5	1
1098		
1097		
1096		
1095		
1094		
1093	09	2
1092	8	1
1091		
1090	6	1
1089		
1088		
1087	5	1

1087|5 represents 10.875

Figure 365. Stem and Leaf and Normal Quantile Plot for Treatment 34

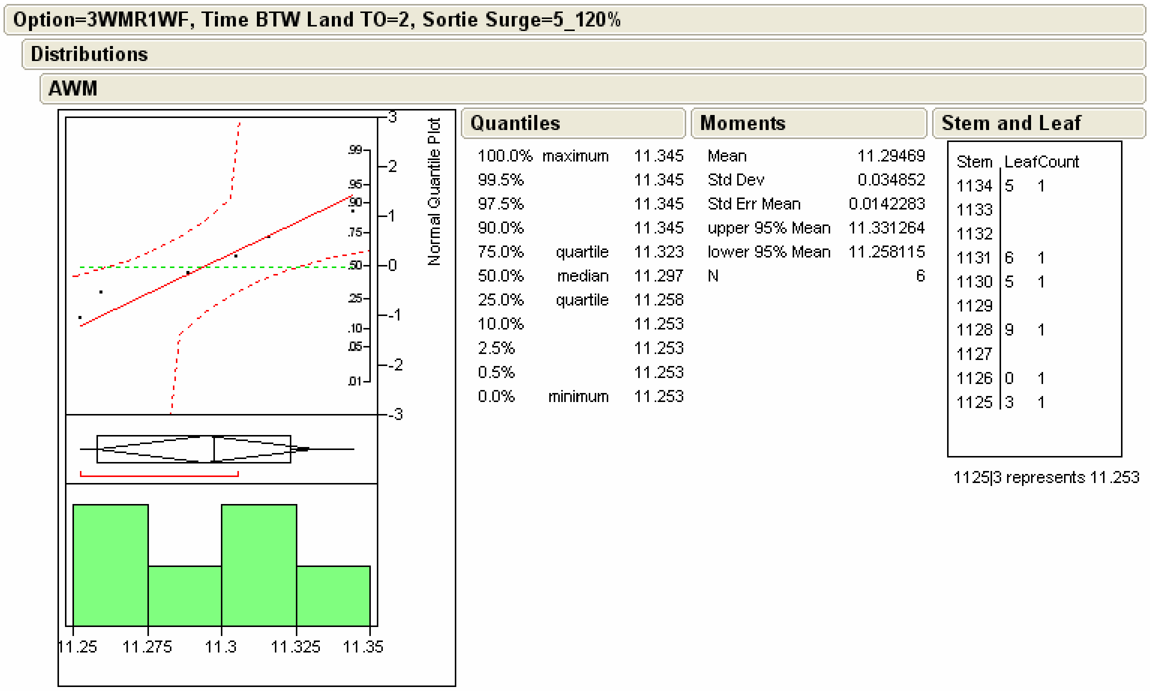


Figure 366. Stem and Leaf and Normal Quantile Plot for Treatment 35

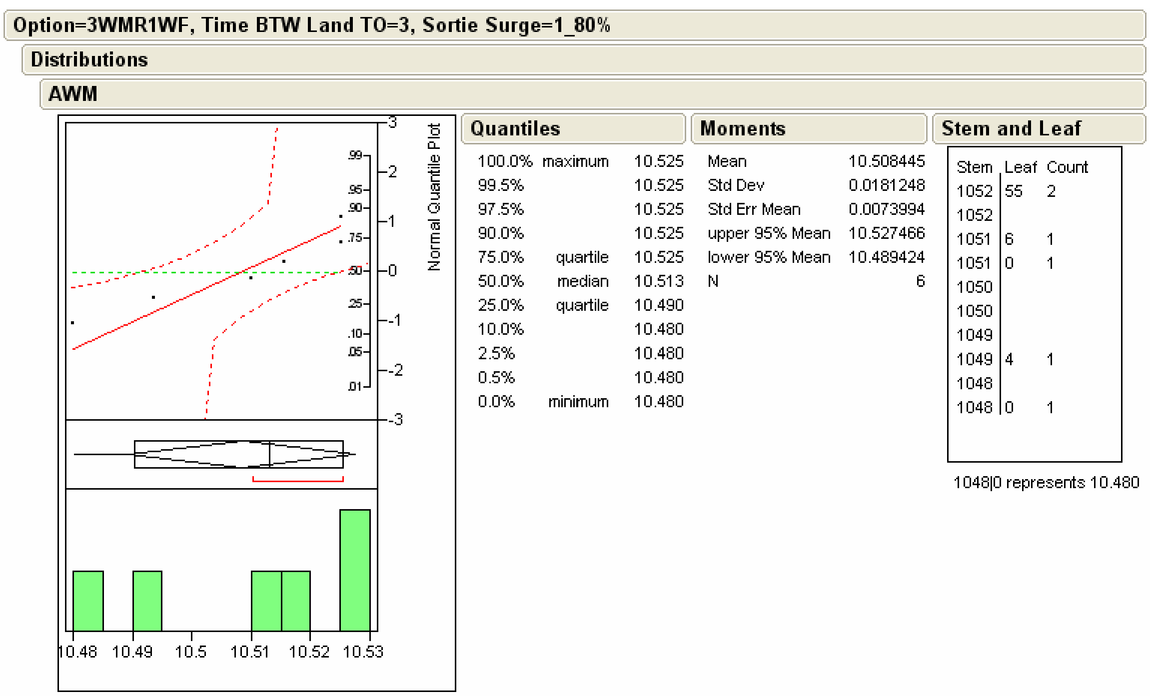


Figure 367. Stem and Leaf and Normal Quantile Plot for Treatment 36

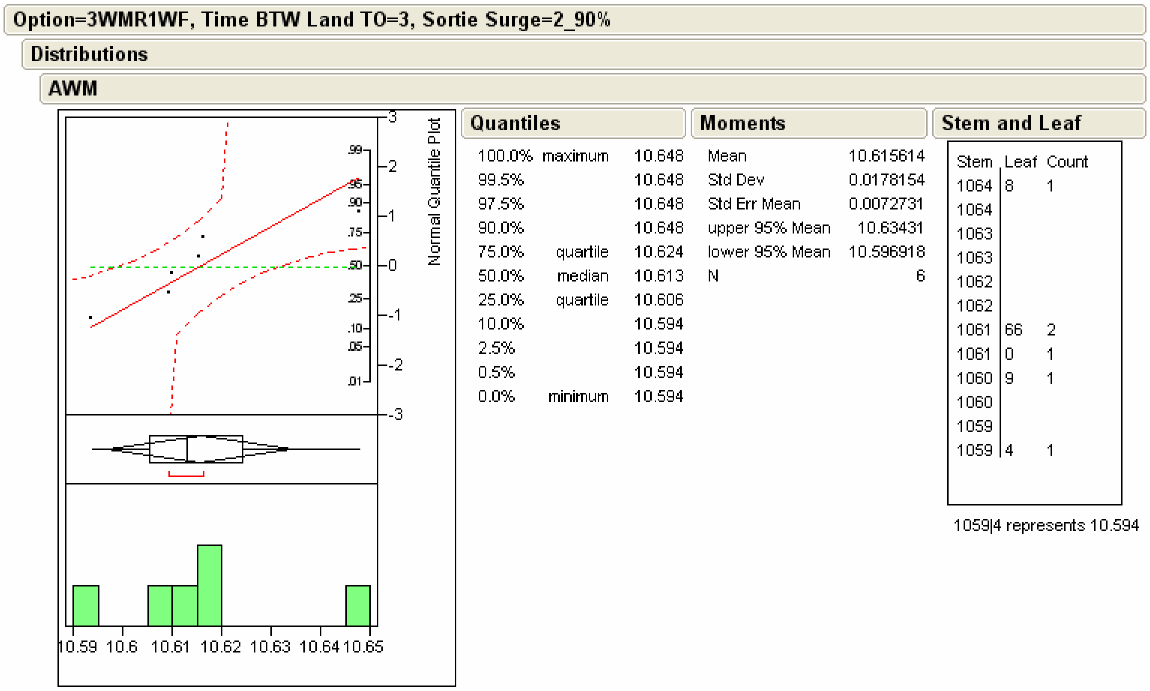


Figure 368. Stem and Leaf and Normal Quantile Plot for Treatment 37

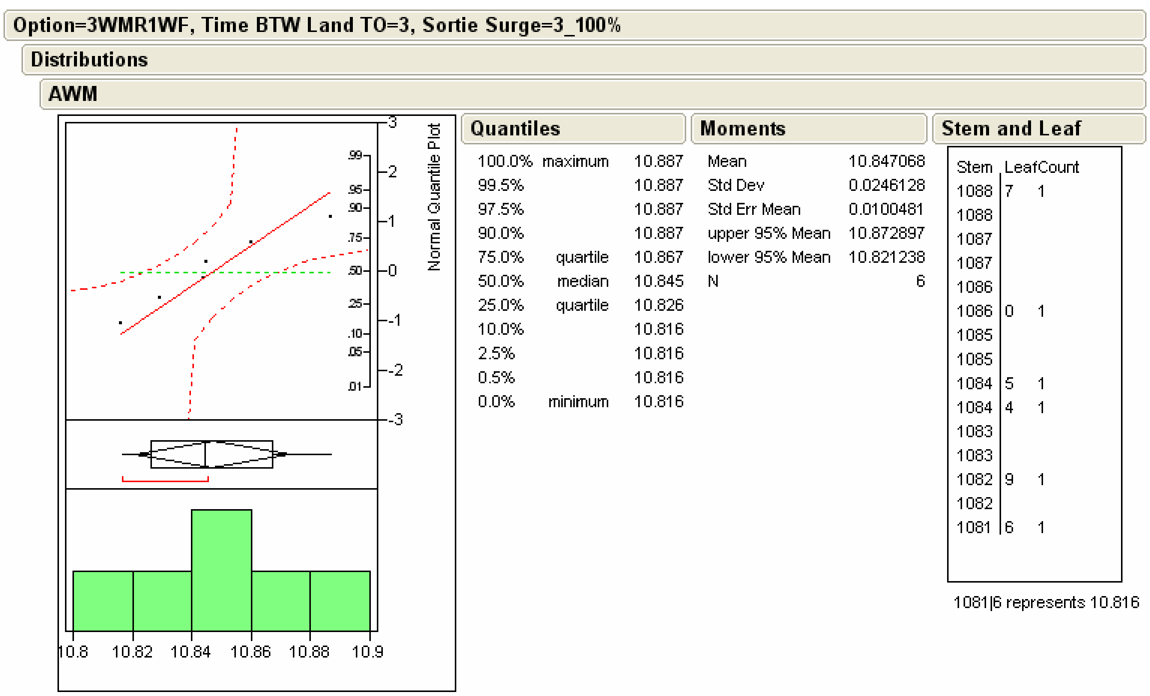
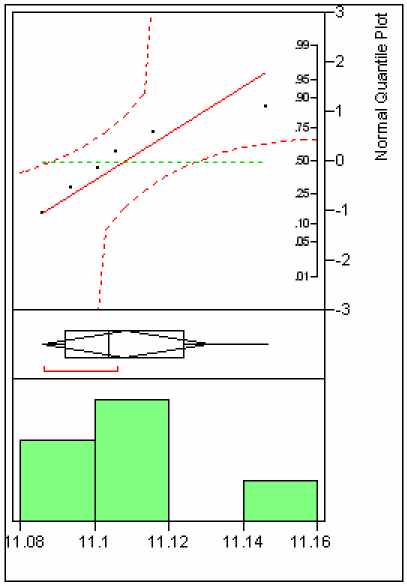


Figure 369. Stem and Leaf and Normal Quantile Plot for Treatment 38

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

AWM



Quantiles

100.0%	maximum	11.147
99.5%		11.147
97.5%		11.147
90.0%		11.147
75.0%	quartile	11.124
50.0%	median	11.104
25.0%	quartile	11.092
10.0%		11.086
2.5%		11.086
0.5%		11.086
0.0%	minimum	11.086

Moments

Mean	11.108421
Std Dev	0.0213276
Std Err Mean	0.0087069
upper 95% Mean	11.130803
lower 95% Mean	11.086039
N	6

Stem and Leaf

Stem	Leaf	Count
1114	7	1
1114		
1113		
1113		
1112		
1112		
1111	6	1
1111		
1110	6	1
1110	1	1
1109		
1109	4	1
1108	6	1

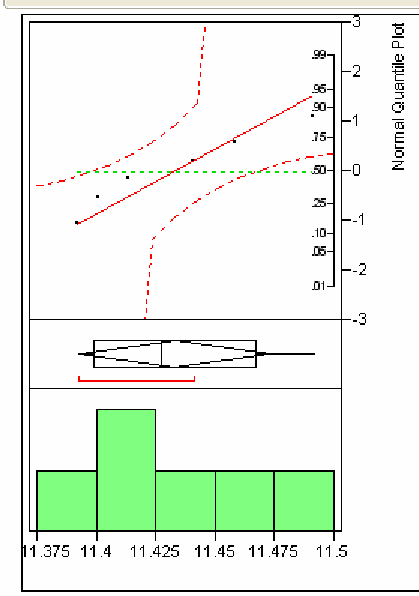
1108|6 represents 11.086

Figure 370. Stem and Leaf and Normal Quantile Plot for Treatment 39

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

AWM



Quantiles

100.0%	maximum	11.492
99.5%		11.492
97.5%		11.492
90.0%		11.492
75.0%	quartile	11.467
50.0%	median	11.427
25.0%	quartile	11.399
10.0%		11.392
2.5%		11.392
0.5%		11.392
0.0%	minimum	11.392

Moments

Mean	11.433242
Std Dev	0.0379445
Std Err Mean	0.0154908
upper 95% Mean	11.473062
lower 95% Mean	11.393421
N	6

Stem and Leaf

Stem	Leaf	Count
1149	2	1
1148		
1147		
1146		
1145	9	1
1144	1	1
1143		
1142		
1141	4	1
1140	2	1
1139	2	1

1139|2 represents 11.392

Figure 371. Stem and Leaf and Normal Quantile Plot for Treatment 40

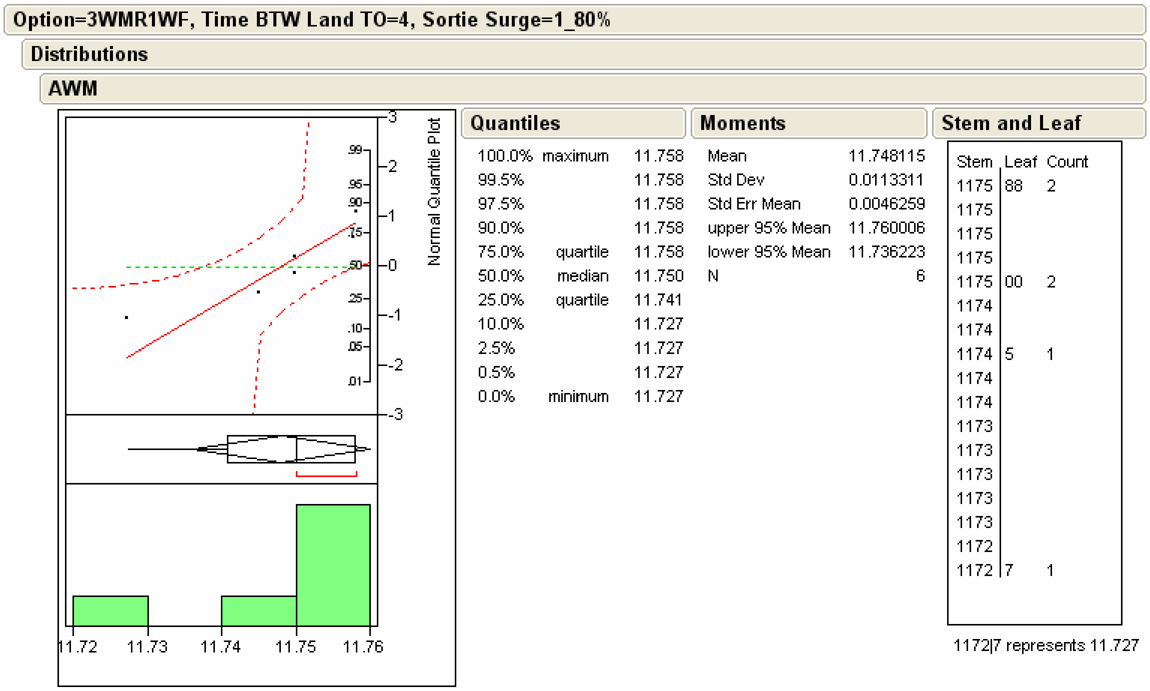


Figure 372. Stem and Leaf and Normal Quantile Plot for Treatment 41

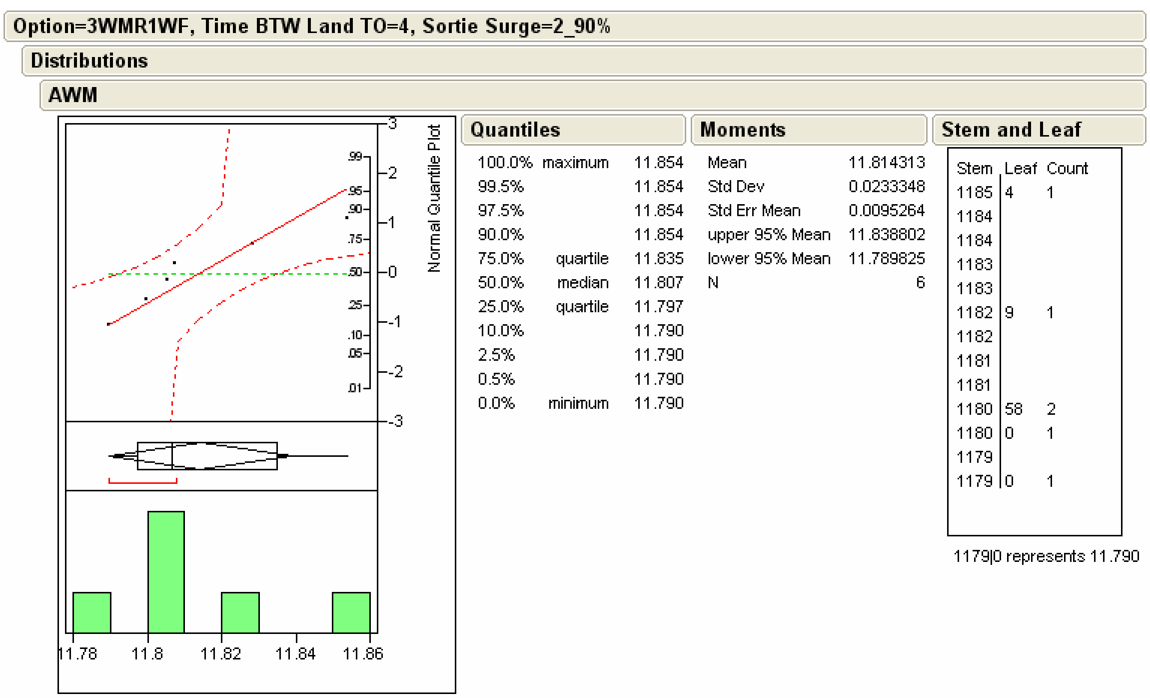
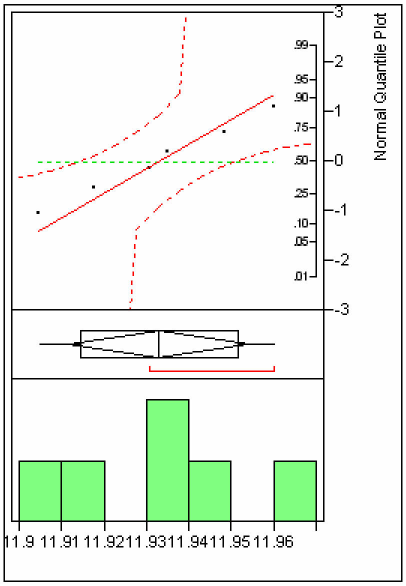


Figure 373. Stem and Leaf and Normal Quantile Plot for Treatment 42

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

AWM



Quantiles

100.0%	maximum	11.960
99.5%		11.960
97.5%		11.960
90.0%		11.960
75.0%	quartile	11.952
50.0%	median	11.933
25.0%	quartile	11.915
10.0%		11.905
2.5%		11.905
0.5%		11.905
0.0%	minimum	11.905

Moments

Mean	11.932892
Std Dev	0.020116
Std Err Mean	0.0082123
upper 95% Mean	11.954002
lower 95% Mean	11.911781
N	6

Stem and Leaf

Stem	Leaf	Count
1196	0	1
1195		
1195		
1194	9	1
1194		
1193	5	1
1193	1	1
1192		
1192		
1191	8	1
1191		
1190	5	1

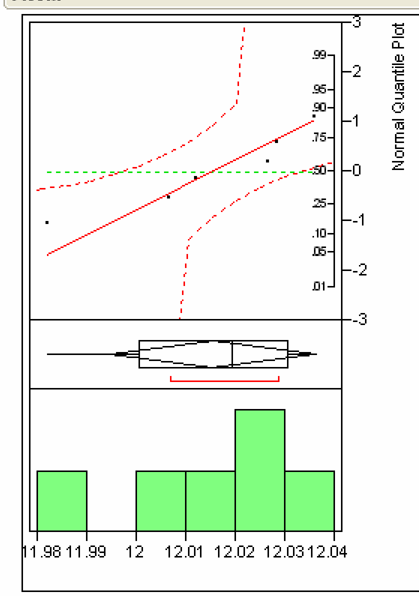
1190|5 represents 11.905

Figure 374. Stem and Leaf and Normal Quantile Plot for Treatment 43

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

AWM



Quantiles

100.0%	maximum	12.036
99.5%		12.036
97.5%		12.036
90.0%		12.036
75.0%	quartile	12.031
50.0%	median	12.020
25.0%	quartile	12.001
10.0%		11.982
2.5%		11.982
0.5%		11.982
0.0%	minimum	11.982

Moments

Mean	12.015529
Std Dev	0.0196323
Std Err Mean	0.0080148
upper 95% Mean	12.036132
lower 95% Mean	11.994926
N	6

Stem and Leaf

Stem	Leaf	Count
1203	6	1
1203		
1202	79	2
1202		
1201		
1201	2	1
1200	7	1
1200		
1199		
1199		
1198		
1198	2	1

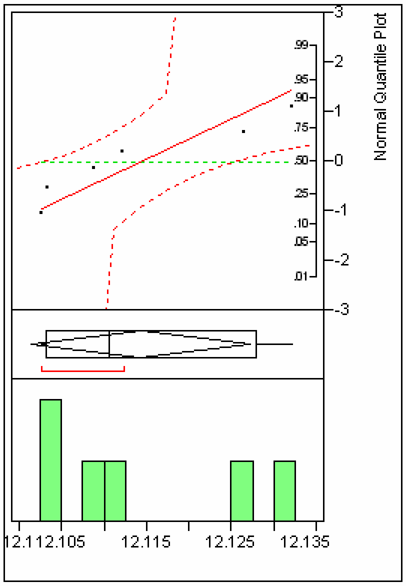
1198|2 represents 11.982

Figure 375. Stem and Leaf and Normal Quantile Plot for Treatment 44

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

AWM



Quantiles

100.0%	maximum	12.132
99.5%		12.132
97.5%		12.132
90.0%		12.132
75.0%	quartile	12.128
50.0%	median	12.111
25.0%	quartile	12.103
10.0%		12.103
2.5%		12.103
0.5%		12.103
0.0%	minimum	12.103

Moments

Mean	12.114355
Std Dev	0.0122866
Std Err Mean	0.005016
upper 95% Mean	12.127249
lower 95% Mean	12.101461
N	6

Stem and Leaf

Stem	Leaf	Count
1213	2	1
1213		
1212		
1212	7	1
1212		
1212		
1212		
1211		
1211		
1211		
1211	2	1
1211		
1210	9	1
1210		
1210		
1210	33	2

1210|3 represents 12.103

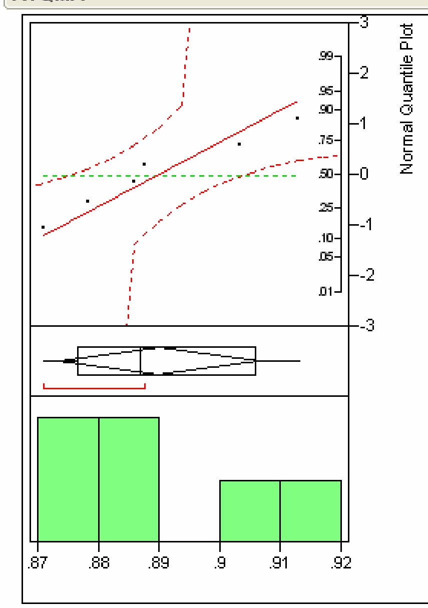
Figure 376. Stem and Leaf and Normal Quantile Plot for Treatment 45

Output Variable ATQMA

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.91310
99.5%		0.91310
97.5%		0.91310
90.0%		0.91310
75.0%	quartile	0.90578
50.0%	median	0.88683
25.0%	quartile	0.87668
10.0%		0.87110
2.5%		0.87110
0.5%		0.87110
0.0%	minimum	0.87110

Moments

Mean	0.889957
Std Dev	0.0156312
Std Err Mean	0.0063814
upper 95% Mean	0.9063609
lower 95% Mean	0.873553
N	6

Stem and Leaf

Stem	Leaf	Count
91	3	1
90		
90	3	1
89		
89		
88	68	2
88		
87	9	1
87	1	1

87|1 represents 0.871

Figure 377. Stem and Leaf and Normal Quantile Plot for Treatment 1

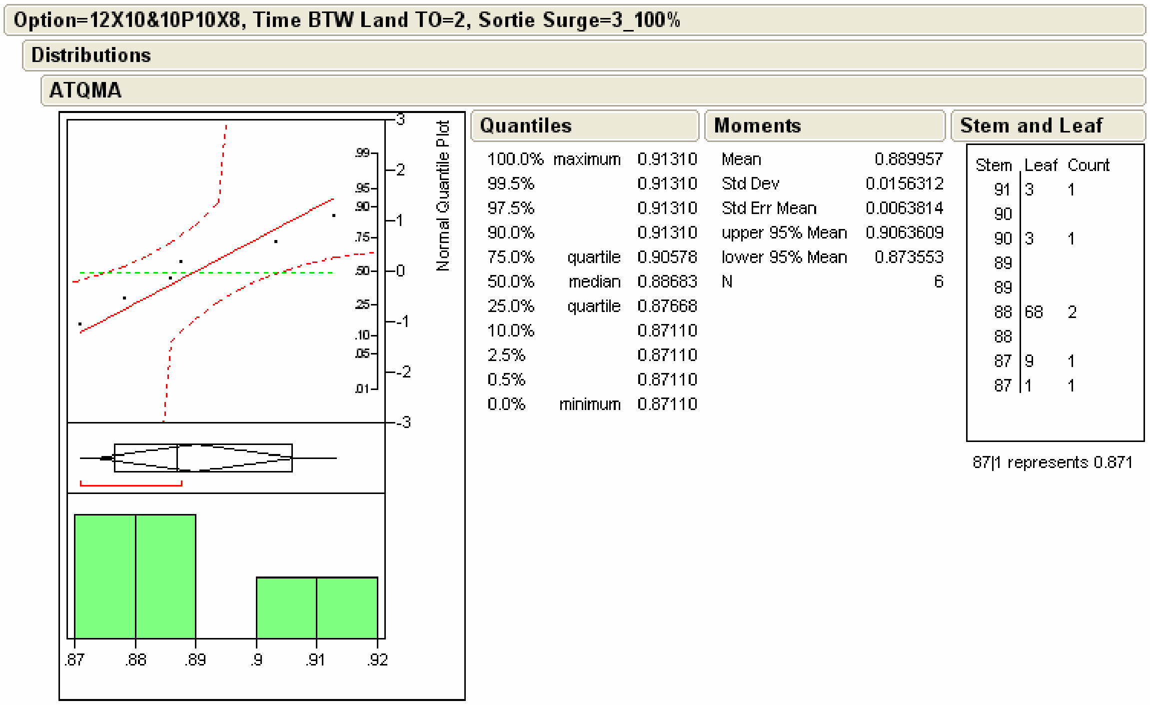


Figure 378. Stem and Leaf and Normal Quantile Plot for Treatment 2

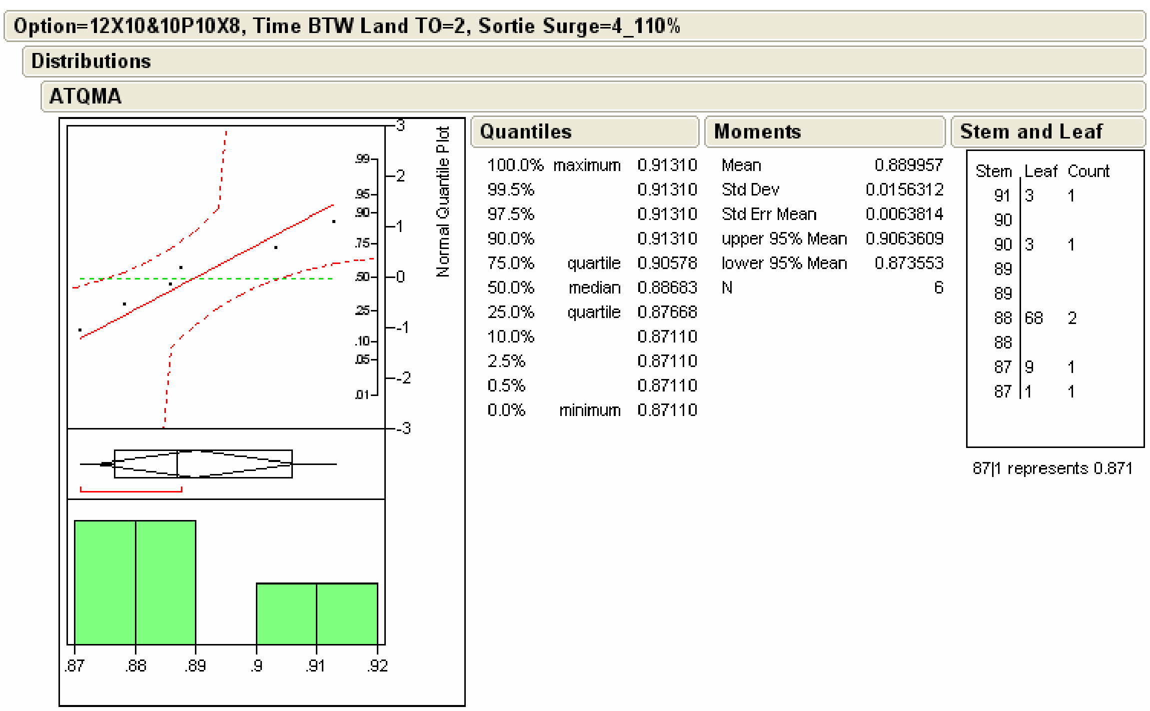
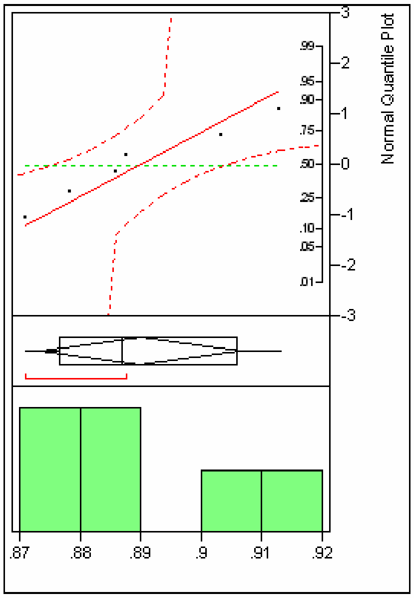


Figure 379. Stem and Leaf and Normal Quantile Plot for Treatment 3

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.91310
99.5%		0.91310
97.5%		0.91310
90.0%		0.91310
75.0%	quartile	0.90578
50.0%	median	0.88683
25.0%	quartile	0.87668
10.0%		0.87110
2.5%		0.87110
0.5%		0.87110
0.0%	minimum	0.87110

Moments

Mean	0.889957
Std Dev	0.0156312
Std Err Mean	0.0063814
upper 95% Mean	0.9063609
lower 95% Mean	0.873553
N	6

Stem and Leaf

Stem	Leaf	Count
91	3	1
90		
90	3	1
89		
89		
88	68	2
88		
87	9	1
87	1	1

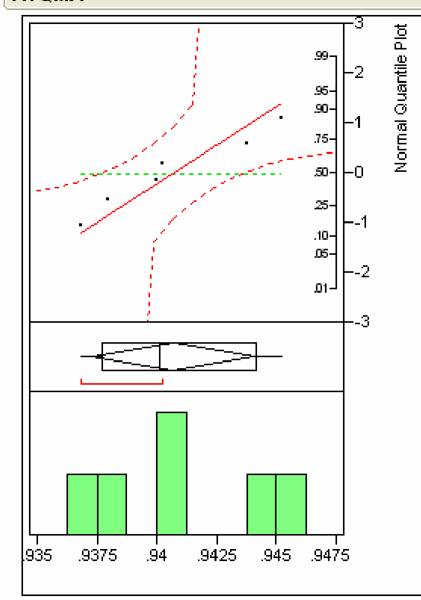
87|1 represents 0.871

Figure 380. Stem and Leaf and Normal Quantile Plot for Treatment 4

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.94524
99.5%		0.94524
97.5%		0.94524
90.0%		0.94524
75.0%	quartile	0.94416
50.0%	median	0.94014
25.0%	quartile	0.93772
10.0%		0.93684
2.5%		0.93684
0.5%		0.93684
0.0%	minimum	0.93684

Moments

Mean	0.9406978
Std Dev	0.0032567
Std Err Mean	0.0013295
upper 95% Mean	0.9441156
lower 95% Mean	0.9372801
N	6

Stem and Leaf

Stem	Leaf	Count
945	2	1
944		
943	8	1
942		
941		
940	02	2
939		
938	0	1
937		
936	8	1

936|8 represents 0.9368

Figure 381. Stem and Leaf and Normal Quantile Plot for Treatment 5

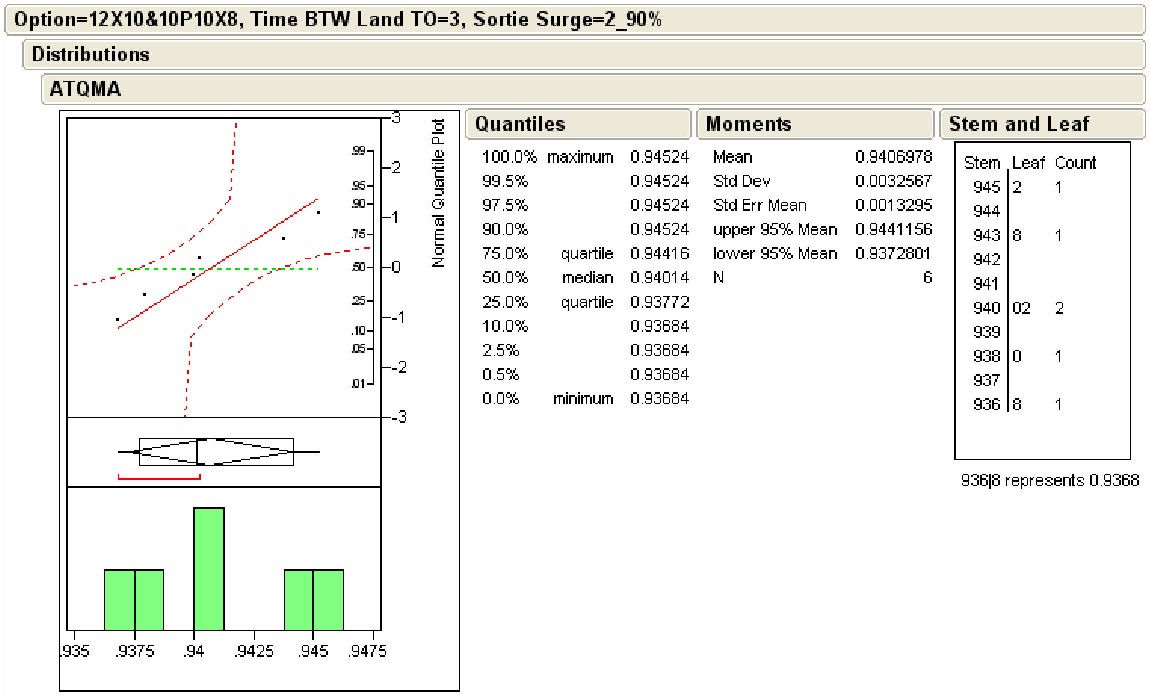


Figure 382. Stem and Leaf and Normal Quantile Plot for Treatment 6

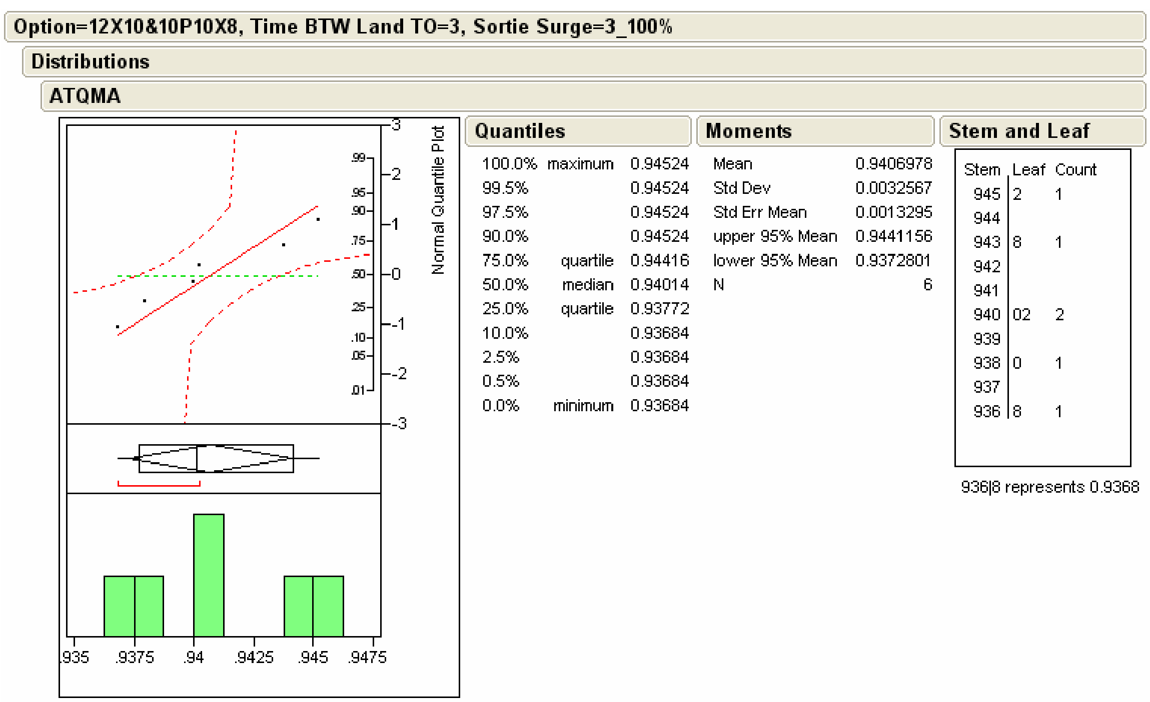
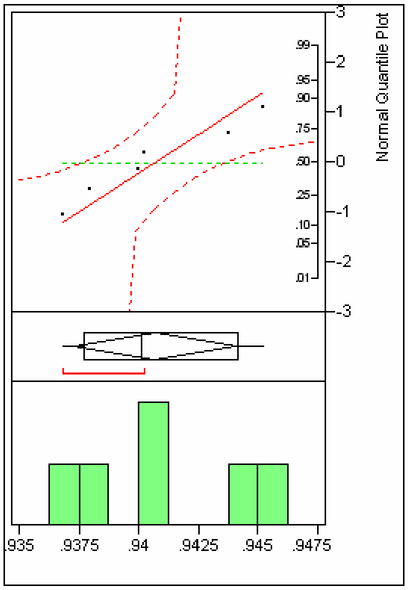


Figure 383. Stem and Leaf and Normal Quantile Plot for Treatment 7

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.94524
99.5%		0.94524
97.5%		0.94524
90.0%		0.94524
75.0%	quartile	0.94416
50.0%	median	0.94014
25.0%	quartile	0.93772
10.0%		0.93684
2.5%		0.93684
0.5%		0.93684
0.0%	minimum	0.93684

Moments

Mean	0.9406978
Std Dev	0.0032567
Std Err Mean	0.0013295
upper 95% Mean	0.9441156
lower 95% Mean	0.9372801
N	6

Stem and Leaf

Stem	Leaf	Count
945	2	1
944		
943	8	1
942		
941		
940	02	2
939		
938	0	1
937		
936	8	1

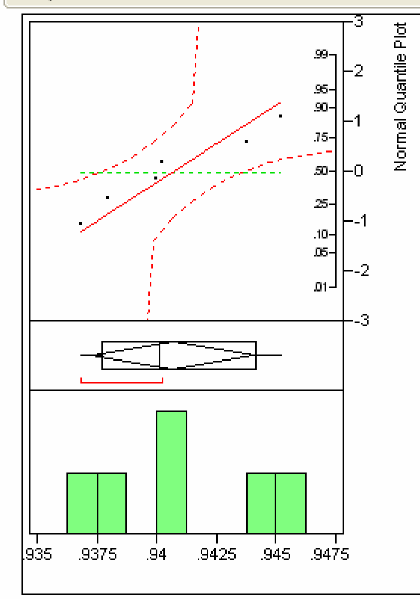
936|8 represents 0.9368

Figure 384. Stem and Leaf and Normal Quantile Plot for Treatment 8

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.94524
99.5%		0.94524
97.5%		0.94524
90.0%		0.94524
75.0%	quartile	0.94416
50.0%	median	0.94014
25.0%	quartile	0.93772
10.0%		0.93684
2.5%		0.93684
0.5%		0.93684
0.0%	minimum	0.93684

Moments

Mean	0.9406978
Std Dev	0.0032567
Std Err Mean	0.0013295
upper 95% Mean	0.9441156
lower 95% Mean	0.9372801
N	6

Stem and Leaf

Stem	Leaf	Count
945	2	1
944		
943	8	1
942		
941		
940	02	2
939		
938	0	1
937		
936	8	1

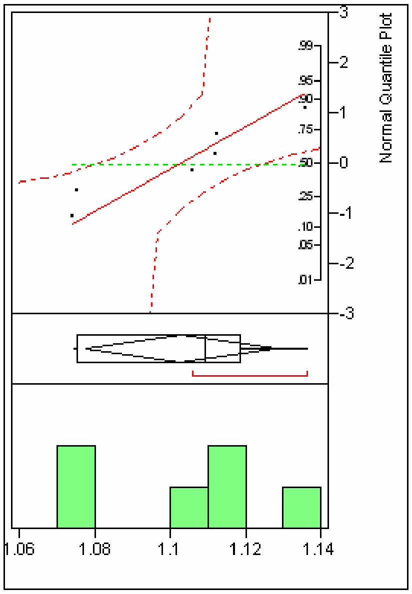
936|8 represents 0.9368

Figure 385. Stem and Leaf and Normal Quantile Plot for Treatment 9

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

ATQMA



Quantiles

100.0%	maximum	1.1363
99.5%		1.1363
97.5%		1.1363
90.0%		1.1363
75.0%	quartile	1.1185
50.0%	median	1.1092
25.0%	quartile	1.0753
10.0%		1.0744
2.5%		1.0744
0.5%		1.0744
0.0%	minimum	1.0744

Moments

Mean	1.1028802
Std Dev	0.023944
Std Err Mean	0.0097751
upper 95% Mean	1.1280079
lower 95% Mean	1.0777525
N	6

Stem and Leaf

Stem	Leaf	Count
113	6	1
113		
112		
112		
111		
111	23	2
110	6	1
110		
109		
109		
108		
108		
107	6	1
107	4	1

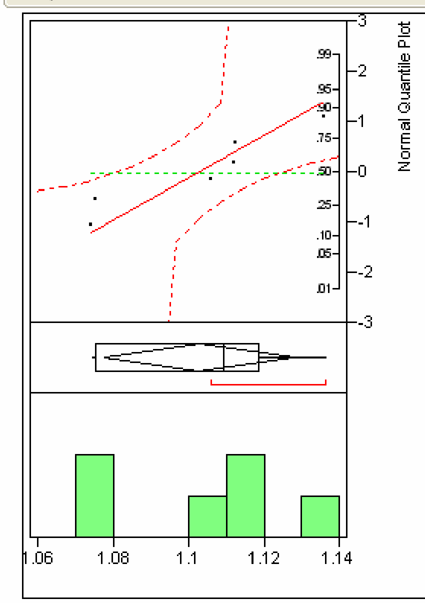
107|4 represents 1.074

Figure 386. Stem and Leaf and Normal Quantile Plot for Treatment 10

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

ATQMA



Quantiles

100.0%	maximum	1.1363
99.5%		1.1363
97.5%		1.1363
90.0%		1.1363
75.0%	quartile	1.1185
50.0%	median	1.1092
25.0%	quartile	1.0753
10.0%		1.0744
2.5%		1.0744
0.5%		1.0744
0.0%	minimum	1.0744

Moments

Mean	1.1028802
Std Dev	0.023944
Std Err Mean	0.0097751
upper 95% Mean	1.1280079
lower 95% Mean	1.0777525
N	6

Stem and Leaf

Stem	Leaf	Count
113	6	1
113		
112		
112		
111		
111	23	2
110	6	1
110		
109		
109		
108		
108		
107	6	1
107	4	1

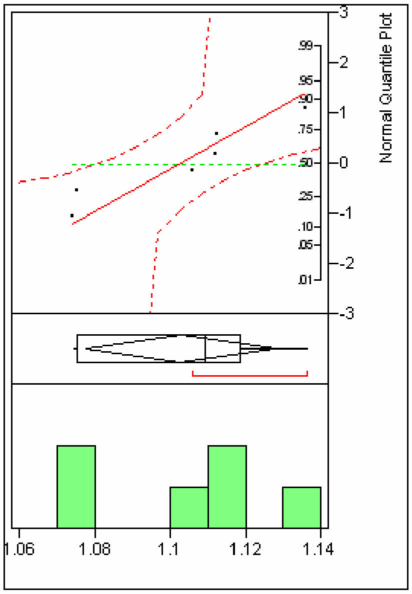
107|4 represents 1.074

Figure 387. Stem and Leaf and Normal Quantile Plot for Treatment 11

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

ATQMA



Quantiles

100.0%	maximum	1.1363
99.5%		1.1363
97.5%		1.1363
90.0%		1.1363
75.0%	quartile	1.1185
50.0%	median	1.1092
25.0%	quartile	1.0753
10.0%		1.0744
2.5%		1.0744
0.5%		1.0744
0.0%	minimum	1.0744

Moments

Mean	1.1028802
Std Dev	0.023944
Std Err Mean	0.0097751
upper 95% Mean	1.1280079
lower 95% Mean	1.0777525
N	6

Stem and Leaf

Stem	Leaf	Count
113	6	1
113		
112		
112		
111		
111	23	2
110	6	1
110		
109		
109		
108		
108		
107	6	1
107	4	1

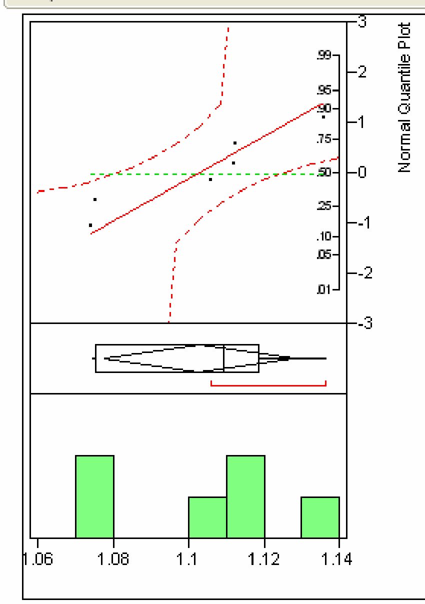
107|4 represents 1.074

Figure 388. Stem and Leaf and Normal Quantile Plot for Treatment 12

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

ATQMA



Quantiles

100.0%	maximum	1.1363
99.5%		1.1363
97.5%		1.1363
90.0%		1.1363
75.0%	quartile	1.1185
50.0%	median	1.1092
25.0%	quartile	1.0753
10.0%		1.0744
2.5%		1.0744
0.5%		1.0744
0.0%	minimum	1.0744

Moments

Mean	1.1028802
Std Dev	0.023944
Std Err Mean	0.0097751
upper 95% Mean	1.1280079
lower 95% Mean	1.0777525
N	6

Stem and Leaf

Stem	Leaf	Count
113	6	1
113		
112		
112		
111		
111	23	2
110	6	1
110		
109		
109		
108		
108		
107	6	1
107	4	1

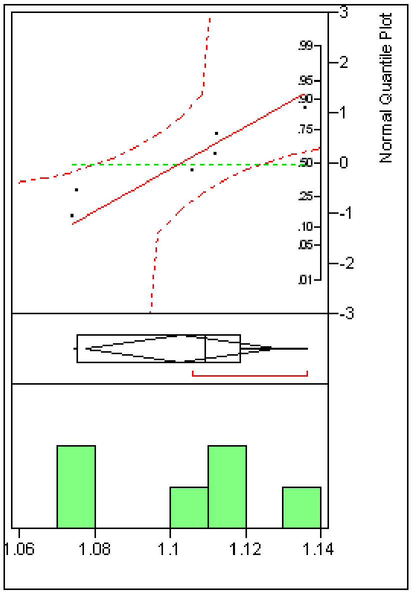
107|4 represents 1.074

Figure 389. Stem and Leaf and Normal Quantile Plot for Treatment 13

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

ATQMA



Quantiles

100.0%	maximum	1.1363
99.5%		1.1363
97.5%		1.1363
90.0%		1.1363
75.0%	quartile	1.1185
50.0%	median	1.1092
25.0%	quartile	1.0753
10.0%		1.0744
2.5%		1.0744
0.5%		1.0744
0.0%	minimum	1.0744

Moments

Mean	1.1028802
Std Dev	0.023944
Std Err Mean	0.0097751
upper 95% Mean	1.1280079
lower 95% Mean	1.0777525
N	6

Stem and Leaf

Stem	Leaf	Count
113	6	1
113		
112		
112		
111		
111	23	2
110	6	1
110		
109		
109		
108		
108		
107	6	1
107	4	1

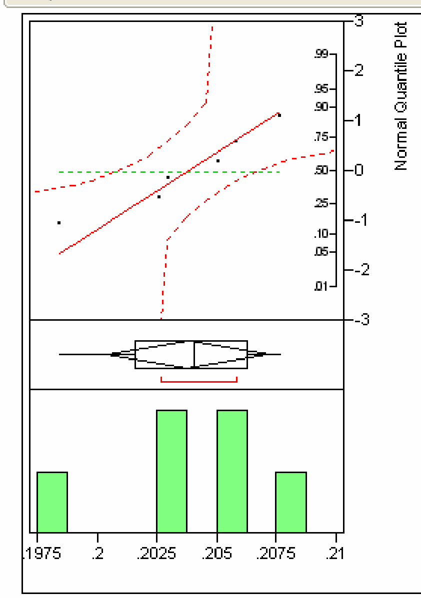
107|4 represents 1.074

Figure 390. Stem and Leaf and Normal Quantile Plot for Treatment 14

Option=3WMF, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.20767
99.5%		0.20767
97.5%		0.20767
90.0%		0.20767
75.0%	quartile	0.20630
50.0%	median	0.20407
25.0%	quartile	0.20161
10.0%		0.19845
2.5%		0.19845
0.5%		0.19845
0.0%	minimum	0.19845

Moments

Mean	0.2037937
Std Dev	0.003209
Std Err Mean	0.0013101
upper 95% Mean	0.2071613
lower 95% Mean	0.2004261
N	6

Stem and Leaf

Stem	Leaf	Count
207	7	1
206		
205	18	2
204		
203	0	1
202	7	1
201		
200		
199		
198	4	1

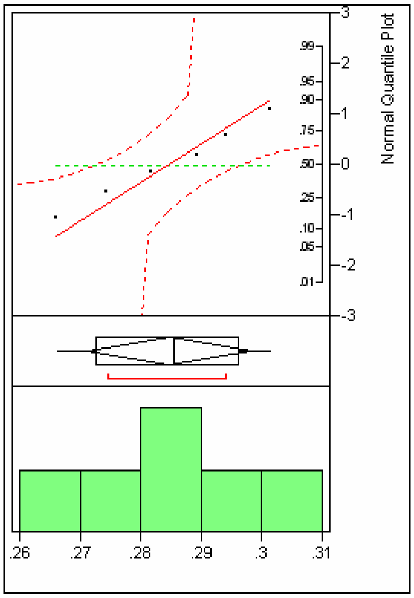
198|4 represents 0.1984

Figure 391. Stem and Leaf and Normal Quantile Plot for Treatment 15

Option=3WMF, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.30149
99.5%		0.30149
97.5%		0.30149
90.0%		0.30149
75.0%	quartile	0.29603
50.0%	median	0.28561
25.0%	quartile	0.27253
10.0%		0.26627
2.5%		0.26627
0.5%		0.26627
0.0%	minimum	0.26627

Moments

Mean	0.284638
Std Dev	0.012996
Std Err Mean	0.0053056
upper 95% Mean	0.2982765
lower 95% Mean	0.2709995
N	6

Stem and Leaf

Stem	Leaf	Count
30	1	1
29		
29	4	1
28	9	1
28	2	1
27	5	1
27		
26	6	1

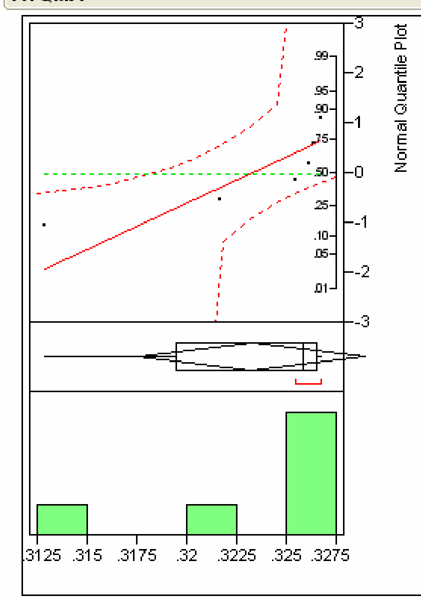
26|6 represents 0.266

Figure 392. Stem and Leaf and Normal Quantile Plot for Treatment 16

Option=3WMF, Time BTW Land TO=2, Sortie Surge=3_100%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.32677
99.5%		0.32677
97.5%		0.32677
90.0%		0.32677
75.0%	quartile	0.32651
50.0%	median	0.32583
25.0%	quartile	0.31950
10.0%		0.31289
2.5%		0.31289
0.5%		0.31289
0.0%	minimum	0.31289

Moments

Mean	0.3232425
Std Dev	0.0054005
Std Err Mean	0.0022047
upper 95% Mean	0.3289099
lower 95% Mean	0.317575
N	6

Stem and Leaf

Stem	Leaf	Count
326	248	3
325	5	1
324		
323		
322		
321	7	1
320		
319		
318		
317		
316		
315		
314		
313		
312	9	1

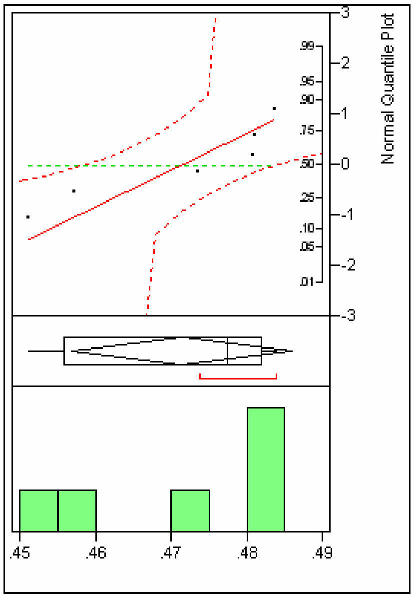
312|9 represents 0.3129

Figure 393. Stem and Leaf and Normal Quantile Plot for Treatment 17

Option=3WMF, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.48391
99.5%		0.48391
97.5%		0.48391
90.0%		0.48391
75.0%	quartile	0.48192
50.0%	median	0.47739
25.0%	quartile	0.45588
10.0%		0.45125
2.5%		0.45125
0.5%		0.45125
0.0%	minimum	0.45125

Moments

Mean	0.4714369
Std Dev	0.0138034
Std Err Mean	0.0056352
upper 95% Mean	0.4859227
lower 95% Mean	0.4569511
N	6

Stem and Leaf

Stem	Leaf	Count
48	114	3
47		
47	4	1
46		
46		
45	7	1
45	1	1

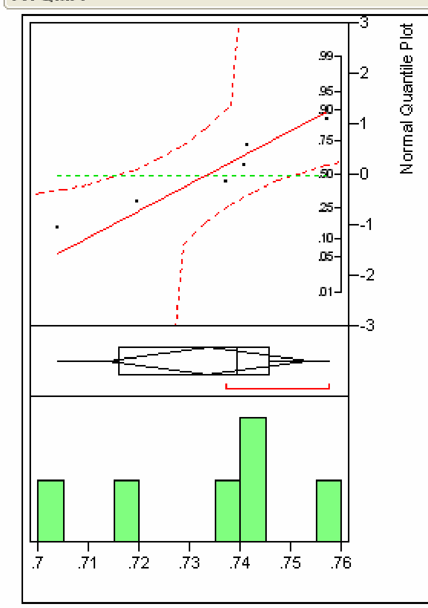
45|1 represents 0.451

Figure 394. Stem and Leaf and Normal Quantile Plot for Treatment 18

Option=3WMF, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.75754
99.5%		0.75754
97.5%		0.75754
90.0%		0.75754
75.0%	quartile	0.74570
50.0%	median	0.73927
25.0%	quartile	0.71593
10.0%		0.70396
2.5%		0.70396
0.5%		0.70396
0.0%	minimum	0.70396

Moments

Mean	0.7336191
Std Dev	0.0188505
Std Err Mean	0.0076957
upper 95% Mean	0.7534015
lower 95% Mean	0.7138367
N	6

Stem and Leaf

Stem	Leaf	Count
75	8	1
75		
74		
74	12	2
73	7	1
73		
72		
72	0	1
71		
71		
70		
70	4	1

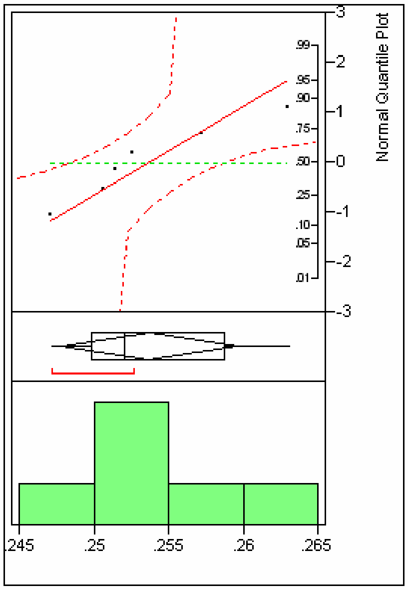
70|4 represents 0.704

Figure 395. Stem and Leaf and Normal Quantile Plot for Treatment 19

Option=3WMF, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.26307
99.5%		0.26307
97.5%		0.26307
90.0%		0.26307
75.0%	quartile	0.25871
50.0%	median	0.25207
25.0%	quartile	0.24982
10.0%		0.24720
2.5%		0.24720
0.5%		0.24720
0.0%	minimum	0.24720

Moments

Mean	0.2537266
Std Dev	0.0056166
Std Err Mean	0.002293
upper 95% Mean	0.2596208
lower 95% Mean	0.2478323
N	6

Stem and Leaf

Stem	Leaf	Count
263	1	1
262		
261		
260		
259		
258		
257	3	1
256		
255		
254		
253		
252	7	1
251	5	1
250	7	1
249		
248		
247	2	1

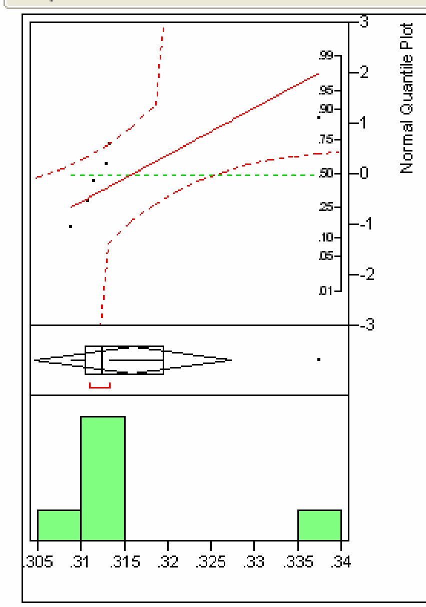
247|2 represents 0.2472

Figure 396. Stem and Leaf and Normal Quantile Plot for Treatment 20

Option=3WMF, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.33760
99.5%		0.33760
97.5%		0.33760
90.0%		0.33760
75.0%	quartile	0.31942
50.0%	median	0.31239
25.0%	quartile	0.31050
10.0%		0.30897
2.5%		0.30897
0.5%		0.30897
0.0%	minimum	0.30897

Moments

Mean	0.3159525
Std Dev	0.0107235
Std Err Mean	0.0043779
upper 95% Mean	0.3272061
lower 95% Mean	0.3046988
N	6

Stem and Leaf

Stem	Leaf	Count
33	8	1
33		
33		
33		
33		
32		
32		
32		
32		
32		
31		
31		
31		
31	233	3
31	1	1
30	9	1

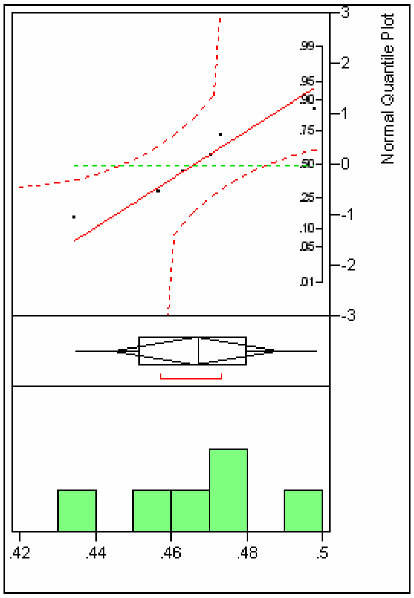
30|9 represents 0.309

Figure 397. Stem and Leaf and Normal Quantile Plot for Treatment 21

Option=3WMF, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.49823
99.5%		0.49823
97.5%		0.49823
90.0%		0.49823
75.0%	quartile	0.47970
50.0%	median	0.46713
25.0%	quartile	0.45154
10.0%		0.43487
2.5%		0.43487
0.5%		0.43487
0.0%	minimum	0.43487

Moments

Mean	0.4663282
Std Dev	0.0208462
Std Err Mean	0.0085104
upper 95% Mean	0.4882049
lower 95% Mean	0.4444515
N	6

Stem and Leaf

Stem	Leaf	Count
49	8	1
49		
48		
48		
47		
47	14	2
46		
46	3	1
45	7	1
45		
44		
44		
43	5	1

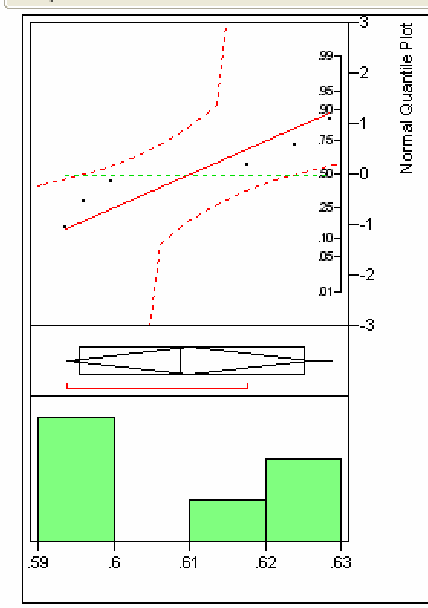
43|5 represents 0.435

Figure 398. Stem and Leaf and Normal Quantile Plot for Treatment 22

Option=3WMF, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.62869
99.5%		0.62869
97.5%		0.62869
90.0%		0.62869
75.0%	quartile	0.62514
50.0%	median	0.60875
25.0%	quartile	0.59549
10.0%		0.59376
2.5%		0.59376
0.5%		0.59376
0.0%	minimum	0.59376

Moments

Mean	0.6099952
Std Dev	0.0152739
Std Err Mean	0.0062355
upper 95% Mean	0.6260241
lower 95% Mean	0.5939662
N	6

Stem and Leaf

Stem	Leaf	Count
62	9	1
62	4	1
61	8	1
61		
60		
60	0	1
59	6	1
59	4	1

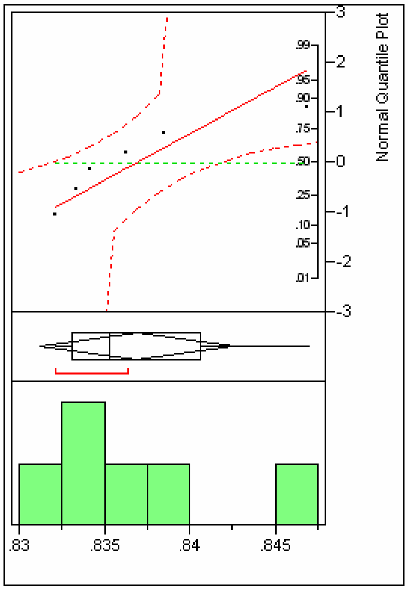
59|4 represents 0.594

Figure 399. Stem and Leaf and Normal Quantile Plot for Treatment 23

Option=3WMF, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.84694
99.5%		0.84694
97.5%		0.84694
90.0%		0.84694
75.0%	quartile	0.84064
50.0%	median	0.83526
25.0%	quartile	0.83306
10.0%		0.83216
2.5%		0.83216
0.5%		0.83216
0.0%	minimum	0.83216

Moments

Mean	0.8369201
Std Dev	0.0054071
Std Err Mean	0.0022074
upper 95% Mean	0.8425945
lower 95% Mean	0.8312457
N	6

Stem and Leaf

Stem	Leaf	Count
846	9	1
845		
844		
843		
842		
841		
840		
839		
838	5	1
837		
836	4	1
835		
834	2	1
833	4	1
832	2	1

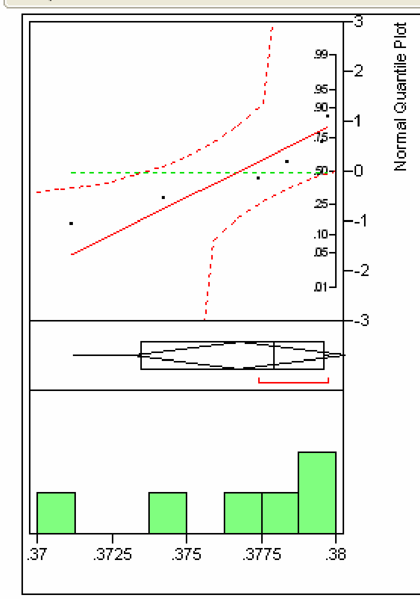
832|2 represents 0.8322

Figure 400. Stem and Leaf and Normal Quantile Plot for Treatment 24

Option=3WMF, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.37975
99.5%		0.37975
97.5%		0.37975
90.0%		0.37975
75.0%	quartile	0.37961
50.0%	median	0.37792
25.0%	quartile	0.37349
10.0%		0.37119
2.5%		0.37119
0.5%		0.37119
0.0%	minimum	0.37119

Moments

Mean	0.3767633
Std Dev	0.0033834
Std Err Mean	0.0013813
upper 95% Mean	0.380314
lower 95% Mean	0.3732127
N	6

Stem and Leaf

Stem	Leaf	Count
379	67	2
378	4	1
377	4	1
376		
375		
374	3	1
373		
372		
371	2	1

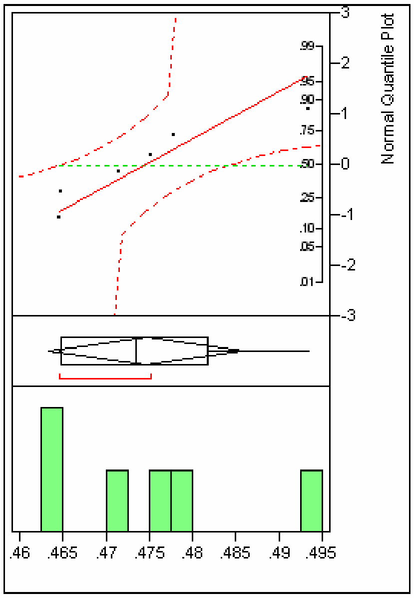
371|2 represents 0.3712

Figure 401. Stem and Leaf and Normal Quantile Plot for Treatment 25

Option=3WMF, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.49346
99.5%		0.49346
97.5%		0.49346
90.0%		0.49346
75.0%	quartile	0.48176
50.0%	median	0.47342
25.0%	quartile	0.46475
10.0%		0.46465
2.5%		0.46465
0.5%		0.46465
0.0%	minimum	0.46465

Moments

Mean	0.4745991
Std Dev	0.0106863
Std Err Mean	0.0043627
upper 95% Mean	0.4858137
lower 95% Mean	0.4633845
N	6

Stem and Leaf

Stem	Leaf	Count
49	3	1
49		
48		
48		
48		
48		
48		
47	8	1
47		
47	5	1
47	2	1
47		
46		
46		
46	55	2

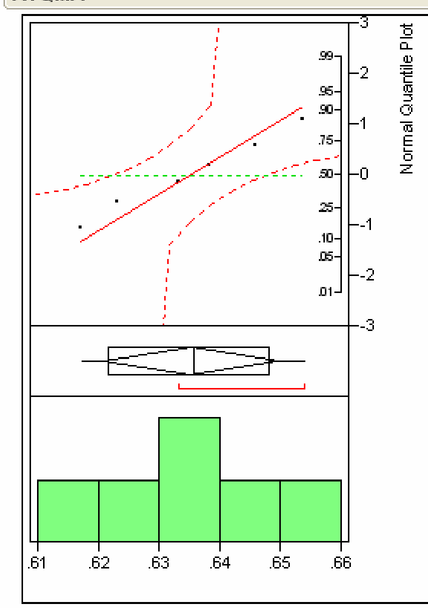
46|5 represents 0.465

Figure 402. Stem and Leaf and Normal Quantile Plot for Treatment 26

Option=3WMF, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.65382
99.5%		0.65382
97.5%		0.65382
90.0%		0.65382
75.0%	quartile	0.64802
50.0%	median	0.63584
25.0%	quartile	0.62170
10.0%		0.61725
2.5%		0.61725
0.5%		0.61725
0.0%	minimum	0.61725

Moments

Mean	0.6353376
Std Dev	0.0137511
Std Err Mean	0.0056139
upper 95% Mean	0.6497684
lower 95% Mean	0.6209067
N	6

Stem and Leaf

Stem	Leaf	Count
65	4	1
64	6	1
64		
63	8	1
63	3	1
62		
62	3	1
61	7	1

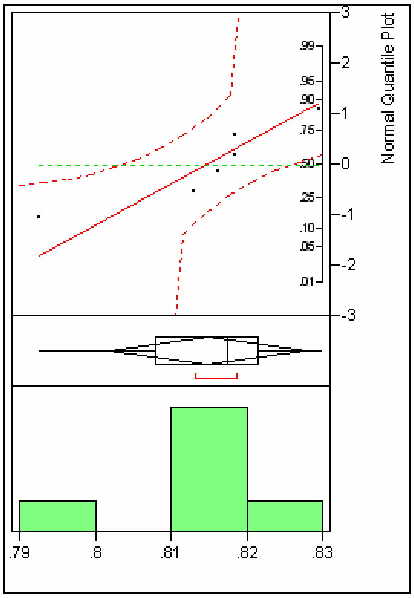
61|7 represents 0.617

Figure 403. Stem and Leaf and Normal Quantile Plot for Treatment 27

Option=3WMF, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.82979
99.5%		0.82979
97.5%		0.82979
90.0%		0.82979
75.0%	quartile	0.82145
50.0%	median	0.81745
25.0%	quartile	0.80801
10.0%		0.79264
2.5%		0.79264
0.5%		0.79264
0.0%	minimum	0.79264

Moments

Mean	0.8148548
Std Dev	0.0122488
Std Err Mean	0.0050006
upper 95% Mean	0.8277092
lower 95% Mean	0.8020004
N	6

Stem and Leaf

Stem	Leaf	Count
83	0	1
82		
82		
81	699	3
81	3	1
80		
80		
79		
79	3	1

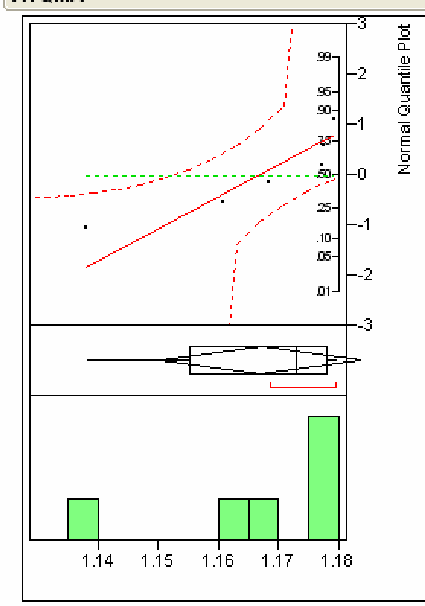
79|3 represents 0.793

Figure 404. Stem and Leaf and Normal Quantile Plot for Treatment 28

Option=3WMF, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

ATQMA



Quantiles

100.0%	maximum	1.1795
99.5%		1.1795
97.5%		1.1795
90.0%		1.1795
75.0%	quartile	1.1781
50.0%	median	1.1730
25.0%	quartile	1.1553
10.0%		1.1383
2.5%		1.1383
0.5%		1.1383
0.0%	minimum	1.1383

Moments

Mean	1.1670403
Std Dev	0.015732
Std Err Mean	0.0064226
upper 95% Mean	1.18355
lower 95% Mean	1.1505306
N	6

Stem and Leaf

Stem	Leaf	Count
117	789	3
117		
116	9	1
116	1	1
115		
115		
114		
114		
113	8	1

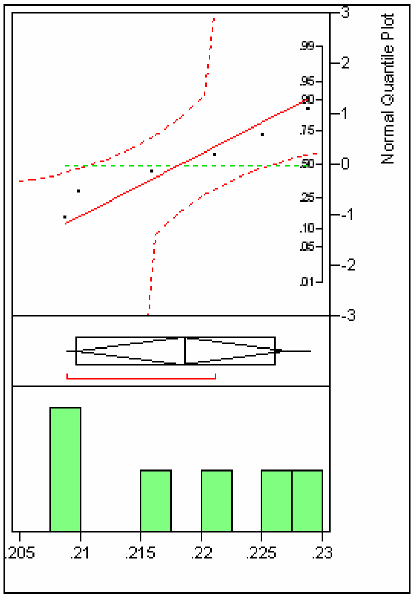
113|8 represents 1.138

Figure 405. Stem and Leaf and Normal Quantile Plot for Treatment 29

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.22898
99.5%		0.22898
97.5%		0.22898
90.0%		0.22898
75.0%	quartile	0.22607
50.0%	median	0.21860
25.0%	quartile	0.20968
10.0%		0.20891
2.5%		0.20891
0.5%		0.20891
0.0%	minimum	0.20891

Moments

Mean	0.2183561
Std Dev	0.0081501
Std Err Mean	0.0033273
upper 95% Mean	0.2269092
lower 95% Mean	0.2098031
N	6

Stem and Leaf

Stem	Leaf	Count
22	9	1
22		
22	5	1
22		
22	1	1
21		
21	6	1
21		
21		
21	0	1
20	9	1

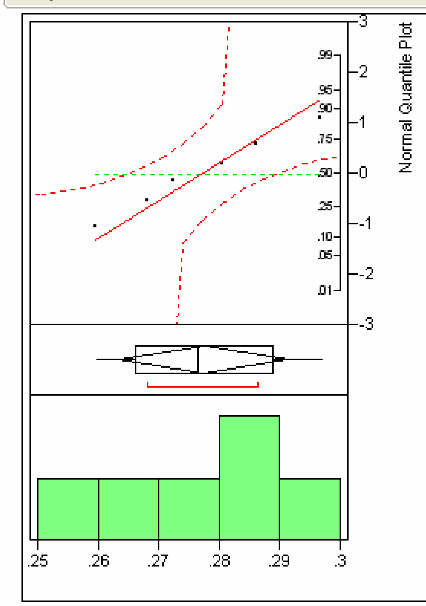
20|9 represents 0.209

Figure 406. Stem and Leaf and Normal Quantile Plot for Treatment 30

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.29684
99.5%		0.29684
97.5%		0.29684
90.0%		0.29684
75.0%	quartile	0.28896
50.0%	median	0.27661
25.0%	quartile	0.26614
10.0%		0.25973
2.5%		0.25973
0.5%		0.25973
0.0%	minimum	0.25973

Moments

Mean	0.2773997
Std Dev	0.0133178
Std Err Mean	0.005437
upper 95% Mean	0.2913759
lower 95% Mean	0.2634235
N	6

Stem and Leaf

Stem	Leaf	Count
29	7	1
29		
29		
29		
28		
28	6	1
28		
28		
28	1	1
27		
27		
27		
27	3	1
27		
26	8	1
26		
26		
26		
26	0	1

26|0 represents 0.260

Figure 407. Stem and Leaf and Normal Quantile Plot for Treatment 31

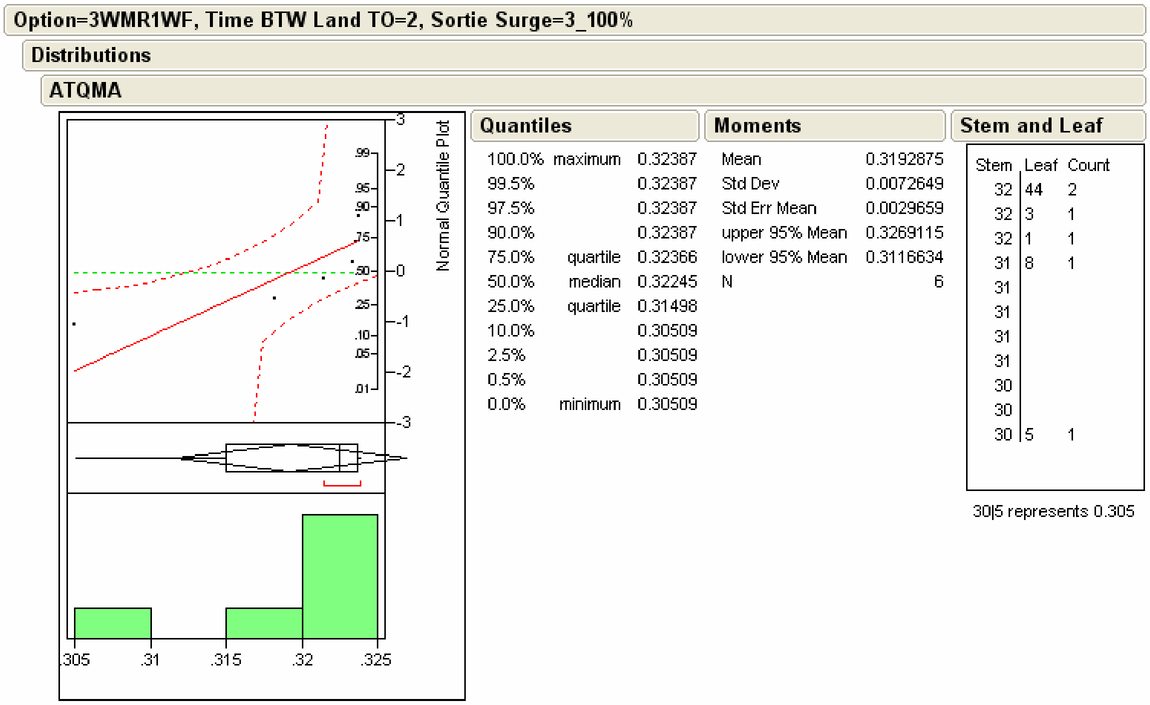


Figure 408. Stem and Leaf and Normal Quantile Plot for Treatment 32

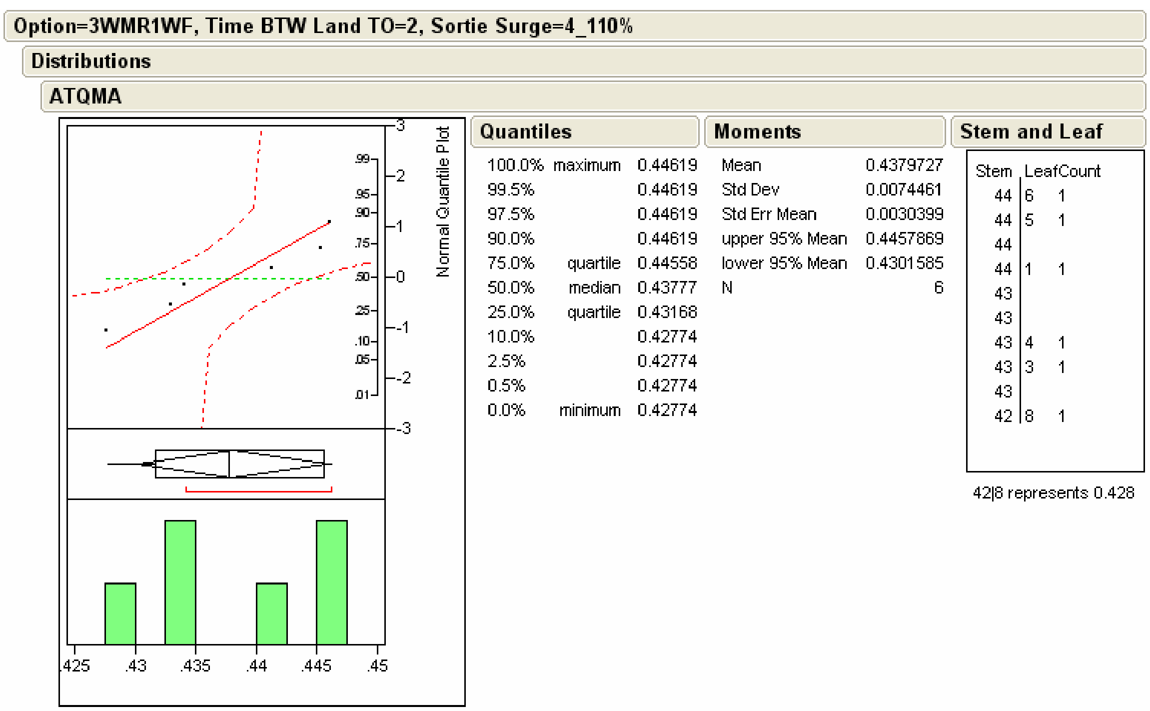
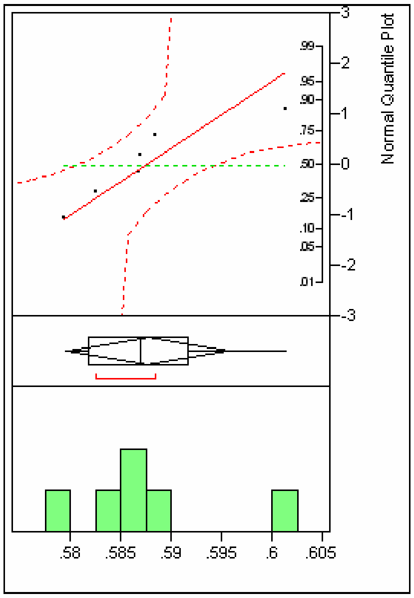


Figure 409. Stem and Leaf and Normal Quantile Plot for Treatment 33

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.60138
99.5%		0.60138
97.5%		0.60138
90.0%		0.60138
75.0%	quartile	0.59174
50.0%	median	0.58697
25.0%	quartile	0.58186
10.0%		0.57952
2.5%		0.57952
0.5%		0.57952
0.0%	minimum	0.57952

Moments

Mean	0.5876663
Std Dev	0.0075027
Std Err Mean	0.003063
upper 95% Mean	0.59554
lower 95% Mean	0.5797927
N	6

Stem and Leaf

Stem	Leaf	Count
60	1	1
59		
59		
59		
59		
59		
58	9	1
58	77	2
58		
58	3	1
58	0	1

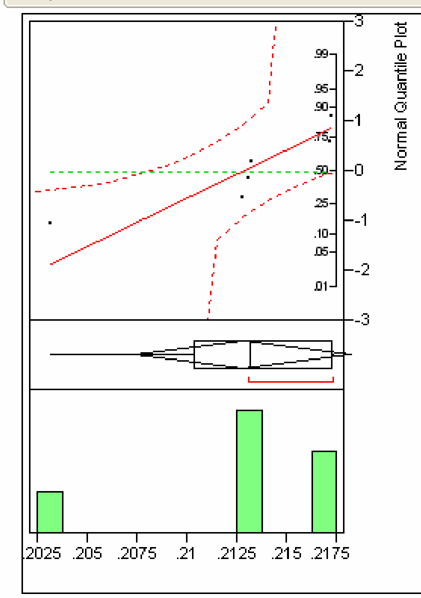
58|0 represents 0.580

Figure 410. Stem and Leaf and Normal Quantile Plot for Treatment 34

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.21733
99.5%		0.21733
97.5%		0.21733
90.0%		0.21733
75.0%	quartile	0.21724
50.0%	median	0.21322
25.0%	quartile	0.21040
10.0%		0.20320
2.5%		0.20320
0.5%		0.20320
0.0%	minimum	0.20320

Moments

Mean	0.21283
Std Dev	0.0051494
Std Err Mean	0.0021022
upper 95% Mean	0.218234
lower 95% Mean	0.2074261
N	6

Stem and Leaf

Stem	Leaf	Count
217	23	2
216		
215		
214		
213	13	2
212	8	1
211		
210		
209		
208		
207		
206		
205		
204		
203	2	1

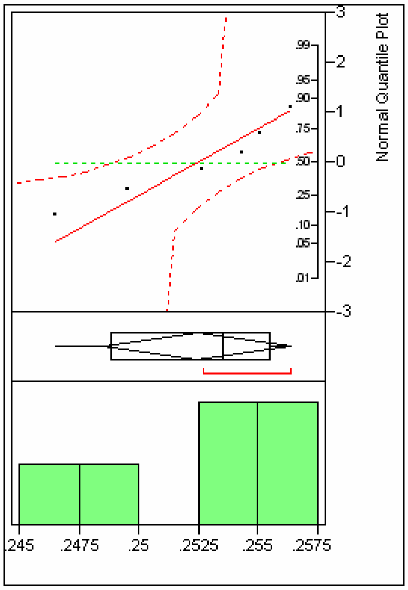
203|2 represents 0.2032

Figure 411. Stem and Leaf and Normal Quantile Plot for Treatment 35

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.25640
99.5%		0.25640
97.5%		0.25640
90.0%		0.25640
75.0%	quartile	0.25547
50.0%	median	0.25352
25.0%	quartile	0.24883
10.0%		0.24653
2.5%		0.24653
0.5%		0.24653
0.0%	minimum	0.24653

Moments

Mean	0.2524525
Std Dev	0.0037364
Std Err Mean	0.0015254
upper 95% Mean	0.2563736
lower 95% Mean	0.2485314
N	6

Stem and Leaf

Stem	Leaf	Count
256	4	1
255	2	1
254	4	1
253		
252	7	1
251		
250		
249	6	1
248		
247		
246	5	1

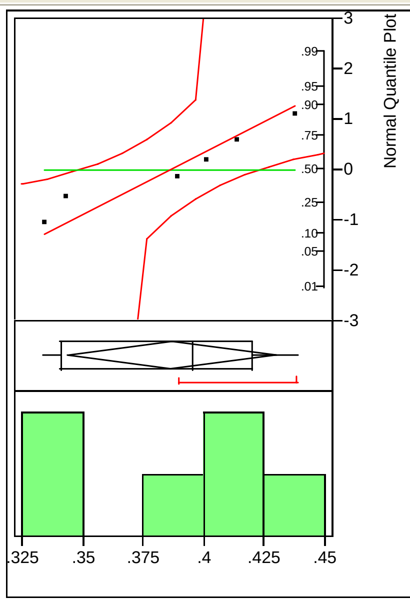
246|5 represents 0.2465

Figure 412. Stem and Leaf and Normal Quantile Plot for Treatment 36

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.43859
99.5%		0.43859
97.5%		0.43859
90.0%		0.43859
75.0%	quartile	0.42020
50.0%	median	0.39581
25.0%	quartile	0.34120
10.0%		0.33469
2.5%		0.33469
0.5%		0.33469
0.0%	minimum	0.33469

Moments

Mean	0.3870582
Std Dev	0.0406461
Std Err Mean	0.0165937
upper 95% Mean	0.4297137
lower 95% Mean	0.3444027
N	6

Stem and Leaf

Stem	Leaf	Count
43	9	1
42		
41	4	1
40	2	1
39	0	1
38		
37		
36		
35		
34	3	1
33	5	1

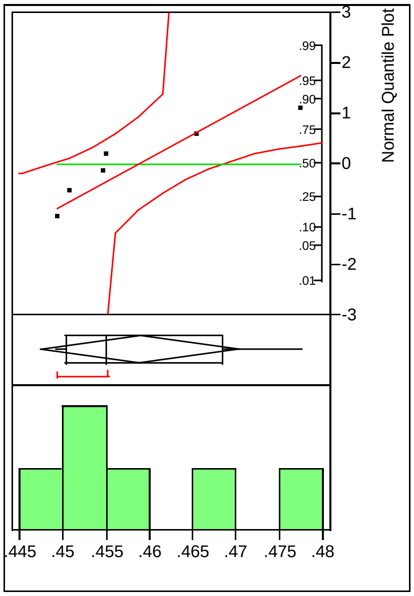
33|5 represents 0.335

Figure 413. Stem and Leaf and Normal Quantile Plot for Treatment 37

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.47761
99.5%		0.47761
97.5%		0.47761
90.0%		0.47761
75.0%	quartile	0.46860
50.0%	median	0.45501
25.0%	quartile	0.45051
10.0%		0.44947
2.5%		0.44947
0.5%		0.44947
0.0%	minimum	0.44947

Moments

Mean	0.4589271
Std Dev	0.0107574
Std Err Mean	0.0043917
upper 95% Mean	0.4702163
lower 95% Mean	0.4476379
N	6

Stem and Leaf

Stem	Leaf	Count
47	8	1
47		
47		
47		
47		
46		
46	6	1
46		
46		
46		
45		
45		
45	55	2
45		
45	1	1
44	9	1

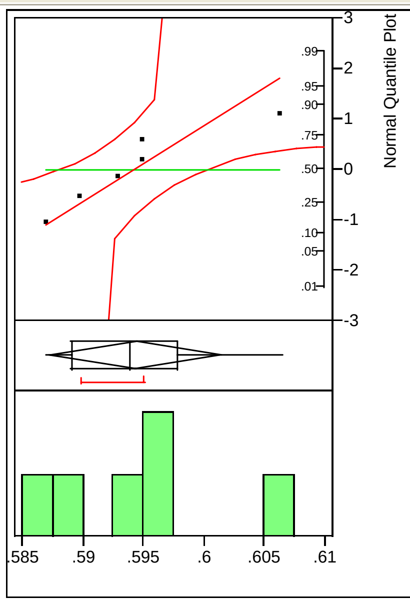
44|9 represents 0.449

Figure 414. Stem and Leaf and Normal Quantile Plot for Treatment 38

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.60645
99.5%		0.60645
97.5%		0.60645
90.0%		0.60645
75.0%	quartile	0.59790
50.0%	median	0.59402
25.0%	quartile	0.58919
10.0%		0.58708
2.5%		0.58708
0.5%		0.58708
0.0%	minimum	0.58708

Moments

Mean	0.5944204
Std Dev	0.0066577
Std Err Mean	0.002718
upper 95% Mean	0.6014073
lower 95% Mean	0.5874335
N	6

Stem and Leaf

Stem	Leaf	Count
60	6	1
60		
60		
60		
59		
59		
59	55	2
59	3	1
59	0	1
58		
58	7	1

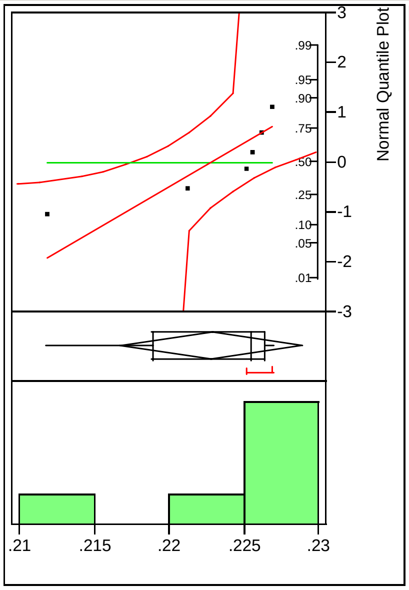
58|7 represents 0.587

Figure 415. Stem and Leaf and Normal Quantile Plot for Treatment 39

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.22697
99.5%		0.22697
97.5%		0.22697
90.0%		0.22697
75.0%	quartile	0.22644
50.0%	median	0.22551
25.0%	quartile	0.21898
10.0%		0.21193
2.5%		0.21193
0.5%		0.21193
0.0%	minimum	0.21193

Moments

Mean	0.2229177
Std Dev	0.0057324
Std Err Mean	0.0023402
upper 95% Mean	0.2289334
lower 95% Mean	0.2169019
N	6

Stem and Leaf

Stem	Leaf	Count
227	0	1
226	3	1
225	37	2
224		
223		
222		
221	3	1
220		
219		
218		
217		
216		
215		
214		
213		
212		
211	9	1

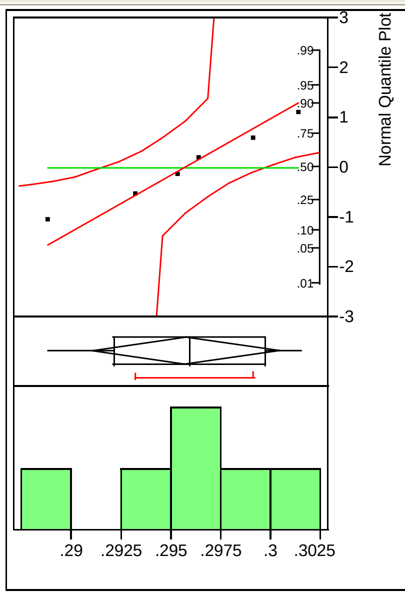
211|9 represents 0.2119

Figure 416. Stem and Leaf and Normal Quantile Plot for Treatment 40

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.30149
99.5%		0.30149
97.5%		0.30149
90.0%		0.30149
75.0%	quartile	0.29975
50.0%	median	0.29595
25.0%	quartile	0.29217
10.0%		0.28891
2.5%		0.28891
0.5%		0.28891
0.0%	minimum	0.28891

Moments

Mean	0.2957898
Std Dev	0.004433
Std Err Mean	0.0018098
upper 95% Mean	0.300442
lower 95% Mean	0.2911376
N	6

Stem and Leaf

Stem	Leaf	Count
301	5	1
300		
299	2	1
298		
297		
296	5	1
295	4	1
294		
293	3	1
292		
291		
290		
289		
288	9	1

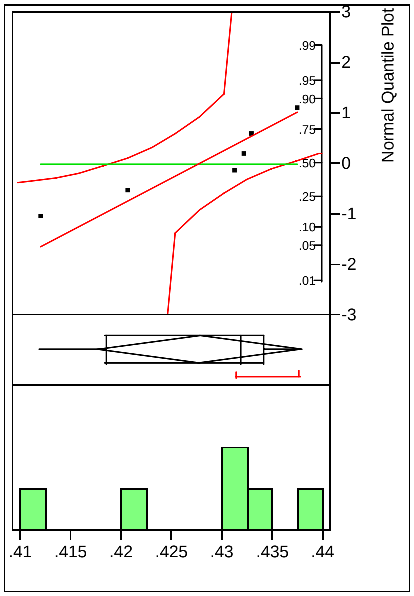
288|9 represents 0.2889

Figure 417. Stem and Leaf and Normal Quantile Plot for Treatment 41

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.43765
99.5%		0.43765
97.5%		0.43765
90.0%		0.43765
75.0%	quartile	0.43429
50.0%	median	0.43192
25.0%	quartile	0.41867
10.0%		0.41216
2.5%		0.41216
0.5%		0.41216
0.0%	minimum	0.41216

Moments

Mean	0.4279444
Std Dev	0.0095208
Std Err Mean	0.0038868
upper 95% Mean	0.4379359
lower 95% Mean	0.417953
N	6

Stem and Leaf

Stem	Leaf	Count
43	8	1
43		
43		
43	23	2
43	1	1
42		
42		
42		
42		
42	1	1
41		
41		
41		
41	2	1

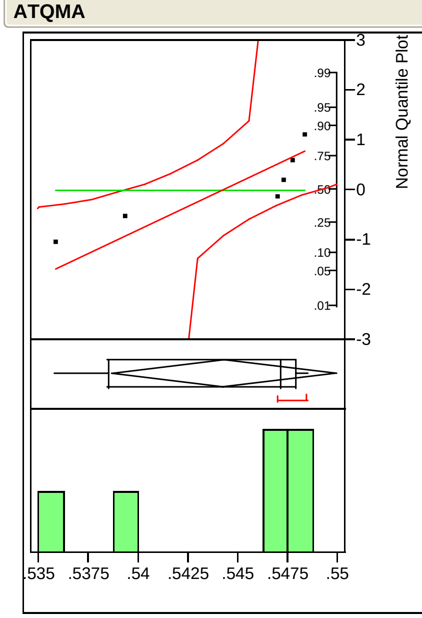
41|2 represents 0.412

Figure 418. Stem and Leaf and Normal Quantile Plot for Treatment 42

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.54846
99.5%		0.54846
97.5%		0.54846
90.0%		0.54846
75.0%	quartile	0.54797
50.0%	median	0.54722
25.0%	quartile	0.53859
10.0%		0.53594
2.5%		0.53594
0.5%		0.53594
0.0%	minimum	0.53594

Moments

Mean	0.5443541
Std Dev	0.0052904
Std Err Mean	0.0021598
upper 95% Mean	0.5499061
lower 95% Mean	0.5388022
N	6

Stem and Leaf

Stem	Leaf	Count
548	5	1
547	148	3
546		
545		
544		
543		
542		
541		
540		
539	5	1
538		
537		
536		
535	9	1

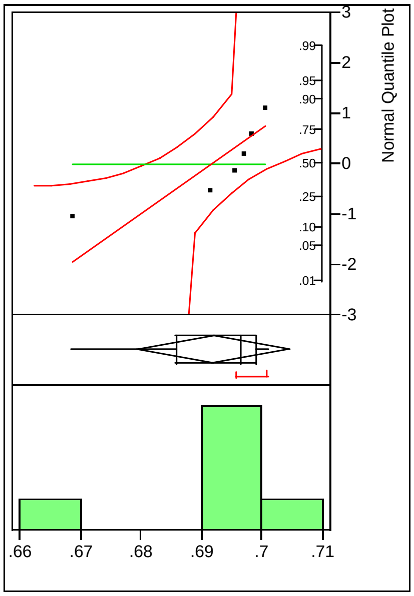
535|9 represents 0.5359

Figure 419. Stem and Leaf and Normal Quantile Plot for Treatment 43

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.70090
99.5%		0.70090
97.5%		0.70090
90.0%		0.70090
75.0%	quartile	0.69915
50.0%	median	0.69650
25.0%	quartile	0.68591
10.0%		0.66887
2.5%		0.66887
0.5%		0.66887
0.0%	minimum	0.66887

Moments

Mean	0.6921555
Std Dev	0.0118234
Std Err Mean	0.0048269
upper 95% Mean	0.7045635
lower 95% Mean	0.6797476
N	6

Stem and Leaf

Stem	Leaf	Count
70	1	1
69	679	3
69	2	1
68		
68		
67		
67		
66	9	1

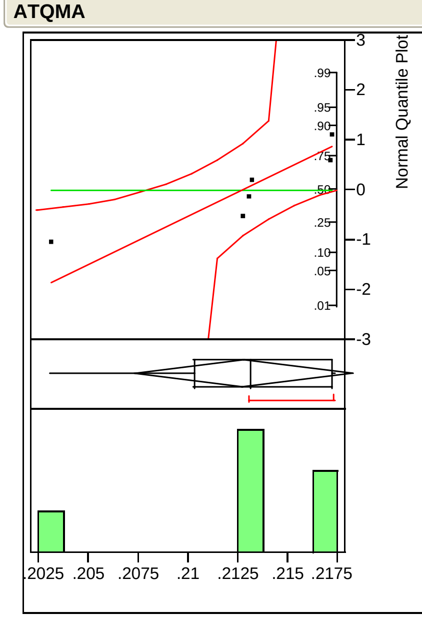
66|9 represents 0.669

Figure 420. Stem and Leaf and Normal Quantile Plot for Treatment 44

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

ATQMA



Quantiles

100.0%	maximum	0.21733
99.5%		0.21733
97.5%		0.21733
90.0%		0.21733
75.0%	quartile	0.21724
50.0%	median	0.21322
25.0%	quartile	0.21040
10.0%		0.20320
2.5%		0.20320
0.5%		0.20320
0.0%	minimum	0.20320

Moments

Mean	0.21283
Std Dev	0.0051494
Std Err Mean	0.0021022
upper 95% Mean	0.218234
lower 95% Mean	0.2074261
N	6

Stem and Leaf

Stem	Leaf	Count
217	23	2
216		
215		
214		
213	13	2
212	8	1
211		
210		
209		
208		
207		
206		
205		
204		
203	2	1

203|2 represents 0.2032

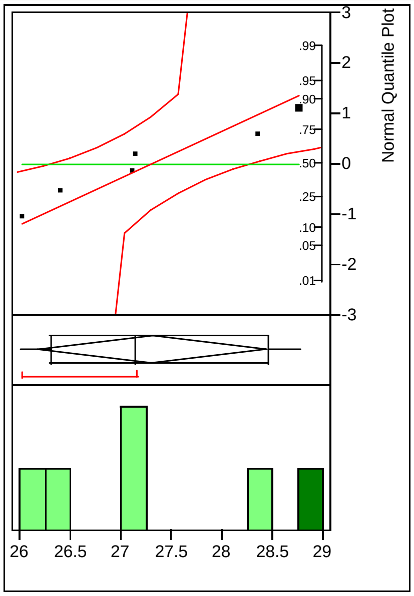
Figure 421. Stem and Leaf and Normal Quantile Plot for Treatment 45

Output Variable Flying Window

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

Flying Window



Quantiles

100.0%	maximum	28.778
99.5%		28.778
97.5%		28.778
90.0%		28.778
75.0%	quartile	28.475
50.0%	median	27.146
25.0%	quartile	26.325
10.0%		26.032
2.5%		26.032
0.5%		26.032
0.0%	minimum	26.032

Moments

Mean	27.316393
Std Dev	1.0736722
Std Err Mean	0.4383248
upper 95% Mean	28.443143
lower 95% Mean	26.189643
N	6

Stem and Leaf

Stem	Leaf	Count
28	8	1
28		
28	4	1
28		
28		
27		
27		
27		
27	2	1
27	1	1
26		
26		
26	4	1
26		
26	0	1

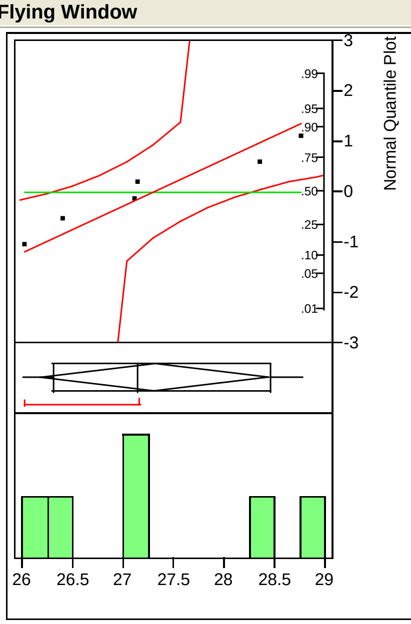
26|0 represents 26.0

Figure 422. Stem and Leaf and Normal Quantile Plot for Treatment 1

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

Flying Window



Quantiles

100.0%	maximum	28.778
99.5%		28.778
97.5%		28.778
90.0%		28.778
75.0%	quartile	28.475
50.0%	median	27.146
25.0%	quartile	26.325
10.0%		26.032
2.5%		26.032
0.5%		26.032
0.0%	minimum	26.032

Moments

Mean	27.316393
Std Dev	1.0736722
Std Err Mean	0.4383248
upper 95% Mean	28.443143
lower 95% Mean	26.189643
N	6

Stem and Leaf

Stem	Leaf	Count
28	8	1
28		
28	4	1
28		
28		
27		
27		
27		
27	2	1
27	1	1
26		
26		
26	4	1
26		
26	0	1

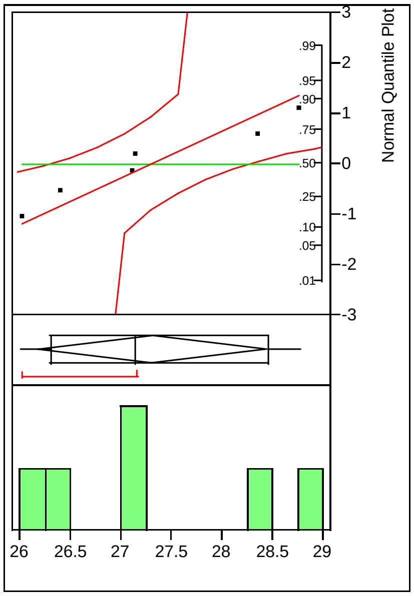
26|0 represents 26.0

Figure 423. Stem and Leaf and Normal Quantile Plot for Treatment 2

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=3_100%

Distributions

Flying Window



Quantiles

100.0%	maximum	28.778
99.5%		28.778
97.5%		28.778
90.0%		28.778
75.0%	quartile	28.475
50.0%	median	27.146
25.0%	quartile	26.325
10.0%		26.032
2.5%		26.032
0.5%		26.032
0.0%	minimum	26.032

Moments

Mean	27.316393
Std Dev	1.0736722
Std Err Mean	0.4383248
upper 95% Mean	28.443143
lower 95% Mean	26.189643
N	6

Stem and Leaf

Stem	Leaf	Count
28	8	1
28		
28	4	1
28		
28		
27		
27		
27		
27	2	1
27	1	1
26		
26		
26	4	1
26		
26	0	1

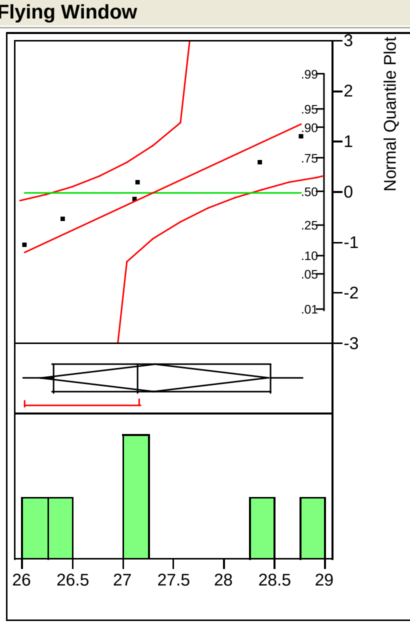
26|0 represents 26.0

Figure 424. Stem and Leaf and Normal Quantile Plot for Treatment 3

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

Flying Window



Quantiles

100.0%	maximum	28.778
99.5%		28.778
97.5%		28.778
90.0%		28.778
75.0%	quartile	28.475
50.0%	median	27.146
25.0%	quartile	26.325
10.0%		26.032
2.5%		26.032
0.5%		26.032
0.0%	minimum	26.032

Moments

Mean	27.316393
Std Dev	1.0736722
Std Err Mean	0.4383248
upper 95% Mean	28.443143
lower 95% Mean	26.189643
N	6

Stem and Leaf

Stem	Leaf	Count
28	8	1
28		
28	4	1
28		
28		
27		
27		
27		
27	2	1
27	1	1
26		
26		
26	4	1
26		
26	0	1

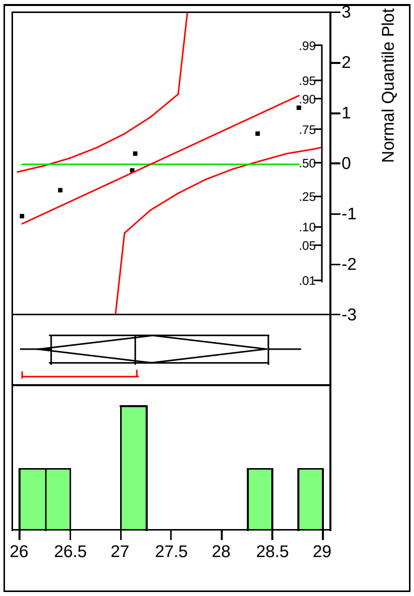
26|0 represents 26.0

Figure 425. Stem and Leaf and Normal Quantile Plot for Treatment 4

Option=12X10&10P10X8, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

Flying Window



Quantiles

100.0%	maximum	28.778
99.5%		28.778
97.5%		28.778
90.0%		28.778
75.0%	quartile	28.475
50.0%	median	27.146
25.0%	quartile	26.325
10.0%		26.032
2.5%		26.032
0.5%		26.032
0.0%	minimum	26.032

Moments

Mean	27.316393
Std Dev	1.0736722
Std Err Mean	0.4383248
upper 95% Mean	28.443143
lower 95% Mean	26.189643
N	6

Stem and Leaf

Stem	Leaf	Count
28	8	1
28		
28	4	1
28		
28		
27		
27		
27		
27	2	1
27	1	1
26		
26		
26	4	1
26		
26	0	1

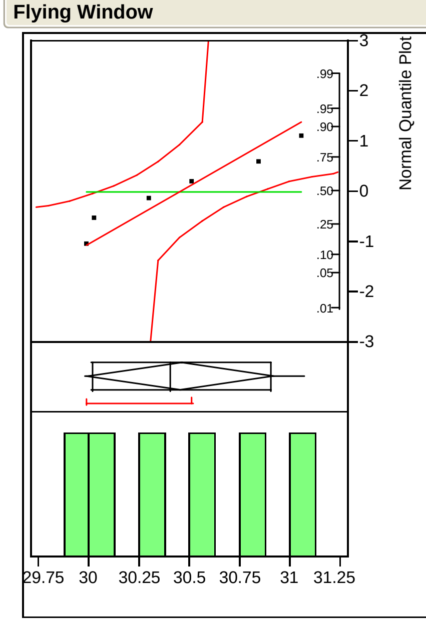
26|0 represents 26.0

Figure 426. Stem and Leaf and Normal Quantile Plot for Treatment 5

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.065
99.5%		31.065
97.5%		31.065
90.0%		31.065
75.0%	quartile	30.908
50.0%	median	30.411
25.0%	quartile	30.022
10.0%		29.994
2.5%		29.994
0.5%		29.994
0.0%	minimum	29.994

Moments

Mean	30.461362
Std Dev	0.4362911
Std Err Mean	0.1781151
upper 95% Mean	30.919221
lower 95% Mean	30.003502
N	6

Stem and Leaf

Stem	Leaf	Count
310	7	1
309		
308	6	1
307		
306		
305	2	1
304		
303	0	1
302		
301		
300	3	1
299	9	1

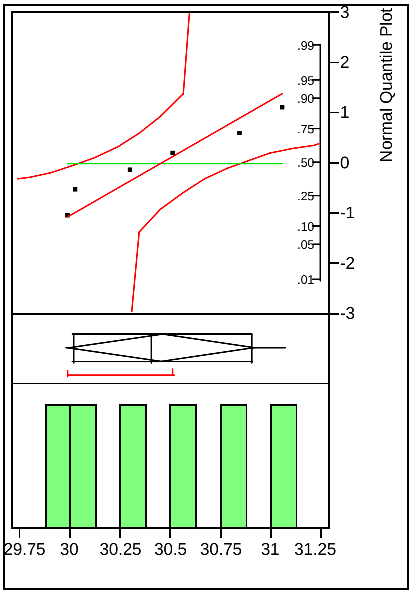
299|9 represents 29.99

Figure 427. Stem and Leaf and Normal Quantile Plot for Treatment 6

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.065
99.5%		31.065
97.5%		31.065
90.0%		31.065
75.0%	quartile	30.908
50.0%	median	30.411
25.0%	quartile	30.022
10.0%		29.994
2.5%		29.994
0.5%		29.994
0.0%	minimum	29.994

Moments

Mean	30.461362
Std Dev	0.4362911
Std Err Mean	0.1781151
upper 95% Mean	30.919221
lower 95% Mean	30.003502
N	6

Stem and Leaf

Stem	Leaf	Count
310	7	1
309		
308	6	1
307		
306		
305	2	1
304		
303	0	1
302		
301		
300	3	1
299	9	1

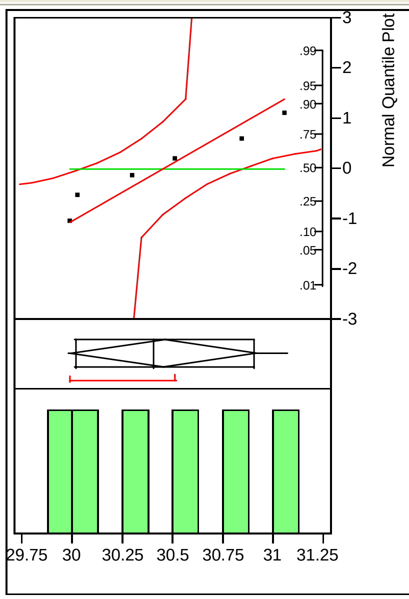
299|9 represents 29.99

Figure 428. Stem and Leaf and Normal Quantile Plot for Treatment 7

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.065
99.5%		31.065
97.5%		31.065
90.0%		31.065
75.0%	quartile	30.908
50.0%	median	30.411
25.0%	quartile	30.022
10.0%		29.994
2.5%		29.994
0.5%		29.994
0.0%	minimum	29.994

Moments

Mean	30.461362
Std Dev	0.4362911
Std Err Mean	0.1781151
upper 95% Mean	30.919221
lower 95% Mean	30.003502
N	6

Stem and Leaf

Stem	Leaf	Count
310	7	1
309		
308	6	1
307		
306		
305	2	1
304		
303	0	1
302		
301		
300	3	1
299	9	1

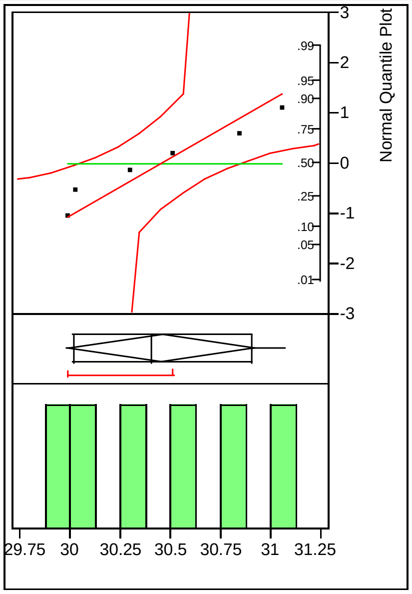
299|9 represents 29.99

Figure 429. Stem and Leaf and Normal Quantile Plot for Treatment 8

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.065
99.5%		31.065
97.5%		31.065
90.0%		31.065
75.0%	quartile	30.908
50.0%	median	30.411
25.0%	quartile	30.022
10.0%		29.994
2.5%		29.994
0.5%		29.994
0.0%	minimum	29.994

Moments

Mean	30.461362
Std Dev	0.4362911
Std Err Mean	0.1781151
upper 95% Mean	30.919221
lower 95% Mean	30.003502
N	6

Stem and Leaf

Stem	Leaf	Count
310	7	1
309		
308	6	1
307		
306		
305	2	1
304		
303	0	1
302		
301		
300	3	1
299	9	1

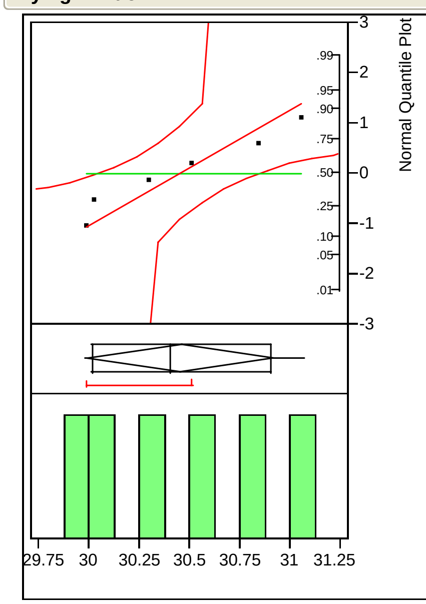
299|9 represents 29.99

Figure 430. Stem and Leaf and Normal Quantile Plot for Treatment 9

Option=12X10&10P10X8, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.065
99.5%		31.065
97.5%		31.065
90.0%		31.065
75.0%	quartile	30.908
50.0%	median	30.411
25.0%	quartile	30.022
10.0%		29.994
2.5%		29.994
0.5%		29.994
0.0%	minimum	29.994

Moments

Mean	30.461362
Std Dev	0.4362911
Std Err Mean	0.1781151
upper 95% Mean	30.919221
lower 95% Mean	30.003502
N	6

Stem and Leaf

Stem	Leaf	Count
310	7	1
309		
308	6	1
307		
306		
305	2	1
304		
303	0	1
302		
301		
300	3	1
299	9	1

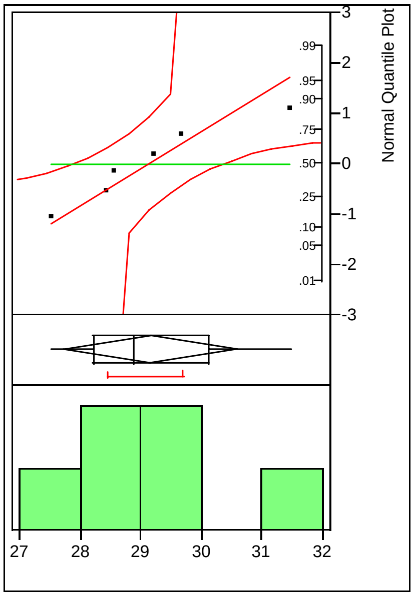
299|9 represents 29.99

Figure 431. Stem and Leaf and Normal Quantile Plot for Treatment 10

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.474
99.5%		31.474
97.5%		31.474
90.0%		31.474
75.0%	quartile	30.142
50.0%	median	28.900
25.0%	quartile	28.232
10.0%		27.547
2.5%		27.547
0.5%		27.547
0.0%	minimum	27.547

Moments

Mean	29.16334
Std Dev	1.3479427
Std Err Mean	0.5502953
upper 95% Mean	30.577919
lower 95% Mean	27.748761
N	6

Stem and Leaf

Stem	Leaf	Count
31	5	1
31		
30		
30		
29	7	1
29	2	1
28	56	2
28		
27	5	1

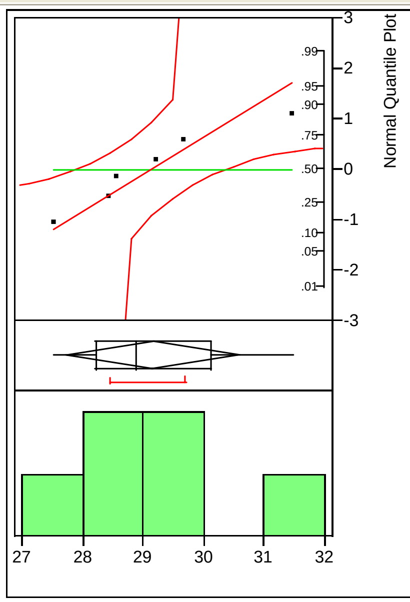
27|5 represents 27.5

Figure 432. Stem and Leaf and Normal Quantile Plot for Treatment 11

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.474
99.5%		31.474
97.5%		31.474
90.0%		31.474
75.0%	quartile	30.142
50.0%	median	28.900
25.0%	quartile	28.232
10.0%		27.547
2.5%		27.547
0.5%		27.547
0.0%	minimum	27.547

Moments

Mean	29.16334
Std Dev	1.3479427
Std Err Mean	0.5502953
upper 95% Mean	30.577919
lower 95% Mean	27.748761
N	6

Stem and Leaf

Stem	Leaf	Count
31	5	1
31		
30		
30		
29	7	1
29	2	1
28	56	2
28		
27	5	1

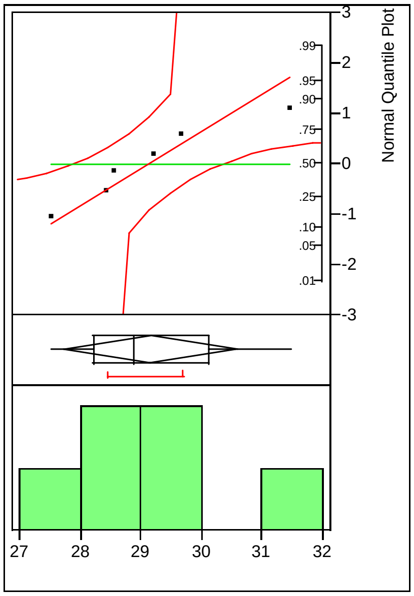
27|5 represents 27.5

Figure 433. Stem and Leaf and Normal Quantile Plot for Treatment 12

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.474
99.5%		31.474
97.5%		31.474
90.0%		31.474
75.0%	quartile	30.142
50.0%	median	28.900
25.0%	quartile	28.232
10.0%		27.547
2.5%		27.547
0.5%		27.547
0.0%	minimum	27.547

Moments

Mean	29.16334
Std Dev	1.3479427
Std Err Mean	0.5502953
upper 95% Mean	30.577919
lower 95% Mean	27.748761
N	6

Stem and Leaf

Stem	Leaf	Count
31	5	1
31		
30		
30		
29	7	1
29	2	1
28	56	2
28		
27	5	1

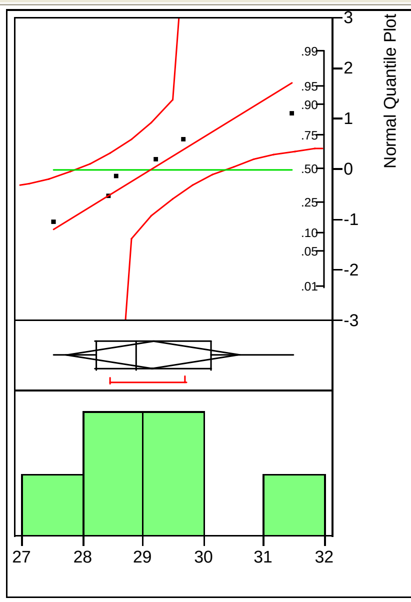
27|5 represents 27.5

Figure 434. Stem and Leaf and Normal Quantile Plot for Treatment 13

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.474
99.5%		31.474
97.5%		31.474
90.0%		31.474
75.0%	quartile	30.142
50.0%	median	28.900
25.0%	quartile	28.232
10.0%		27.547
2.5%		27.547
0.5%		27.547
0.0%	minimum	27.547

Moments

Mean	29.16334
Std Dev	1.3479427
Std Err Mean	0.5502953
upper 95% Mean	30.577919
lower 95% Mean	27.748761
N	6

Stem and Leaf

Stem	Leaf	Count
31	5	1
31		
30		
30		
29	7	1
29	2	1
28	56	2
28		
27	5	1

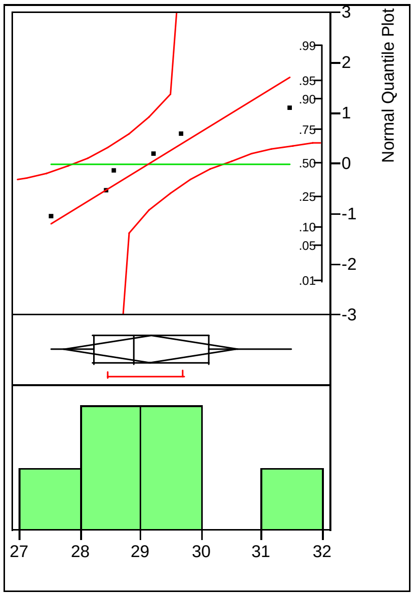
27|5 represents 27.5

Figure 435. Stem and Leaf and Normal Quantile Plot for Treatment 14

Option=12X10&10P10X8, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

Flying Window



Quantiles

100.0%	maximum	31.474
99.5%		31.474
97.5%		31.474
90.0%		31.474
75.0%	quartile	30.142
50.0%	median	28.900
25.0%	quartile	28.232
10.0%		27.547
2.5%		27.547
0.5%		27.547
0.0%	minimum	27.547

Moments

Mean	29.16334
Std Dev	1.3479427
Std Err Mean	0.5502953
upper 95% Mean	30.577919
lower 95% Mean	27.748761
N	6

Stem and Leaf

Stem	Leaf	Count
31	5	1
31		
30		
30		
29	7	1
29	2	1
28	56	2
28		
27	5	1

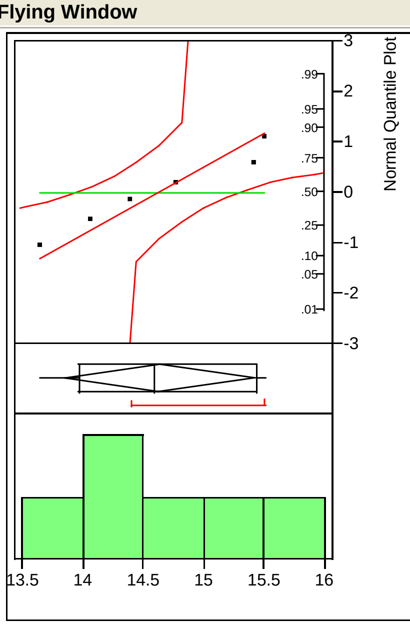
27|5 represents 27.5

Figure 436. Stem and Leaf and Normal Quantile Plot for Treatment 15

Option=3WMF, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

Flying Window



Quantiles

100.0%	maximum	15.508
99.5%		15.508
97.5%		15.508
90.0%		15.508
75.0%	quartile	15.442
50.0%	median	14.593
25.0%	quartile	13.974
10.0%		13.662
2.5%		13.662
0.5%		13.662
0.0%	minimum	13.662

Moments

Mean	14.642419
Std Dev	0.7361806
Std Err Mean	0.3005445
upper 95% Mean	15.414993
lower 95% Mean	13.869845
N	6

Stem and Leaf

Stem	Leaf	Count
15	45	2
15		
15		
14	8	1
14		
14	4	1
14		
14	1	1
13		
13	7	1

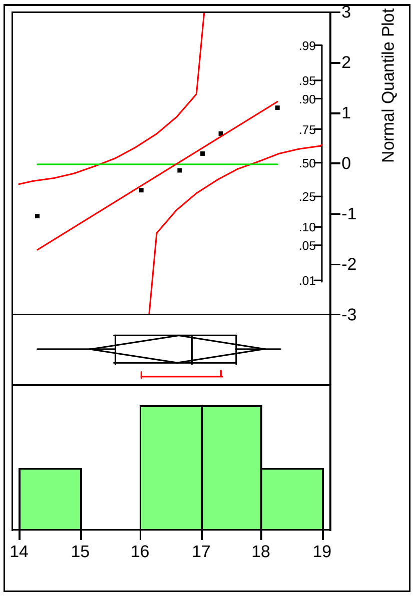
13|7 represents 13.7

Figure 437. Stem and Leaf and Normal Quantile Plot for Treatment 16

Option=3WMF, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

Flying Window



Quantiles

100.0%	maximum	18.288
99.5%		18.288
97.5%		18.288
90.0%		18.288
75.0%	quartile	17.578
50.0%	median	16.853
25.0%	quartile	15.602
10.0%		14.322
2.5%		14.322
0.5%		14.322
0.0%	minimum	14.322

Moments

Mean	16.614312
Std Dev	1.3505474
Std Err Mean	0.5513587
upper 95% Mean	18.031625
lower 95% Mean	15.196999
N	6

Stem and Leaf

Stem	Leaf	Count
18	3	1
17		
17	13	2
16	7	1
16	0	1
15		
15		
14		
14	3	1

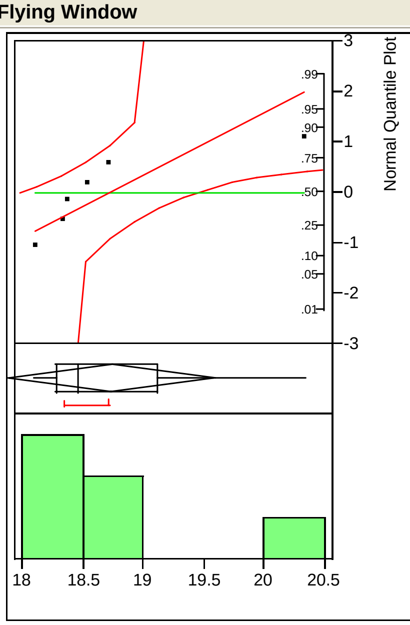
14|3 represents 14.3

Figure 438. Stem and Leaf and Normal Quantile Plot for Treatment 17

Option=3WMF, Time BTW Land TO=2, Sortie Surge=3_100%

Distributions

Flying Window



Quantiles

100.0%	maximum	20.341
99.5%		20.341
97.5%		20.341
90.0%		20.341
75.0%	quartile	19.127
50.0%	median	18.467
25.0%	quartile	18.291
10.0%		18.114
2.5%		18.114
0.5%		18.114
0.0%	minimum	18.114

Moments

Mean	18.743614
Std Dev	0.8087895
Std Err Mean	0.3301869
upper 95% Mean	19.592387
lower 95% Mean	17.894842
N	6

Stem and Leaf

Stem	Leaf	Count
20	3	1
20		
19		
19		
19		
19		
19		
18		
18	7	1
18	445	3
18		
18	1	1

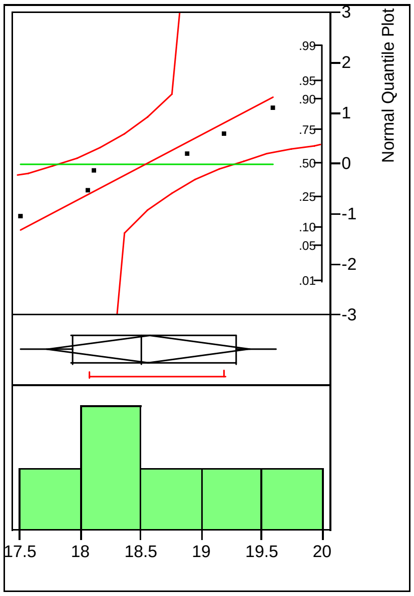
18|1 represents 18.1

Figure 439. Stem and Leaf and Normal Quantile Plot for Treatment 18

Option=3WMF, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

Flying Window



Quantiles

100.0%	maximum	19.602
99.5%		19.602
97.5%		19.602
90.0%		19.602
75.0%	quartile	19.298
50.0%	median	18.510
25.0%	quartile	17.939
10.0%		17.525
2.5%		17.525
0.5%		17.525
0.0%	minimum	17.525

Moments

Mean	18.570011
Std Dev	0.7866603
Std Err Mean	0.3211527
upper 95% Mean	19.395561
lower 95% Mean	17.744462
N	6

Stem and Leaf

Stem	Leaf	Count
19	6	1
19		
19	2	1
19		
18	9	1
18		
18		
18		
18	11	2
17		
17		
17	5	1

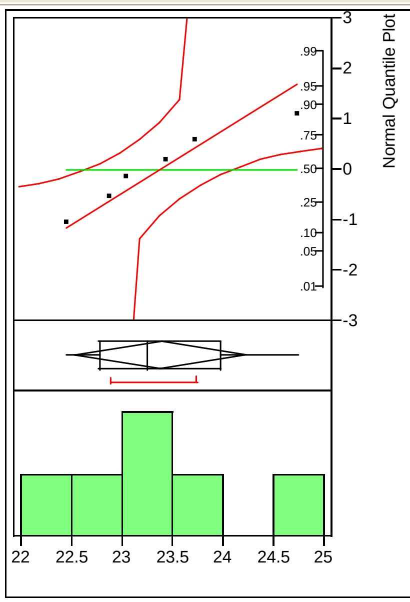
17|5 represents 17.5

Figure 440. Stem and Leaf and Normal Quantile Plot for Treatment 19

Option=3WMF, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

Flying Window



Quantiles

100.0%	maximum	24.744
99.5%		24.744
97.5%		24.744
90.0%		24.744
75.0%	quartile	23.991
50.0%	median	23.253
25.0%	quartile	22.782
10.0%		22.463
2.5%		22.463
0.5%		22.463
0.0%	minimum	22.463

Moments

Mean	23.390223
Std Dev	0.798172
Std Err Mean	0.3258524
upper 95% Mean	24.227853
lower 95% Mean	22.552593
N	6

Stem and Leaf

Stem	Leaf	Count
24	7	1
24		
24		
24		
23		
23	7	1
23	5	1
23		
23	1	1
22	9	1
22		
22	5	1

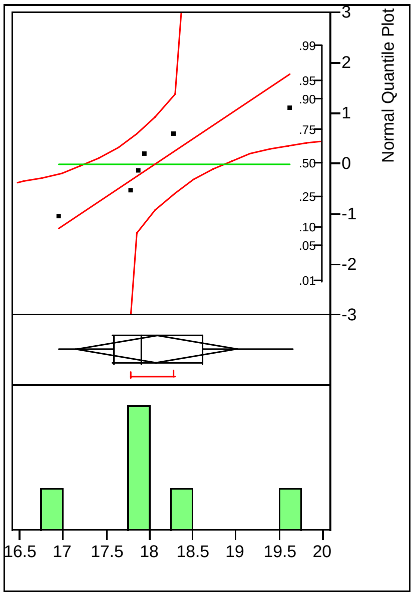
22|5 represents 22.5

Figure 441. Stem and Leaf and Normal Quantile Plot for Treatment 20

Option=3WMF, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

Flying Window



Quantiles

100.0%	maximum	19.638
99.5%		19.638
97.5%		19.638
90.0%		19.638
75.0%	quartile	18.626
50.0%	median	17.919
25.0%	quartile	17.590
10.0%		16.974
2.5%		16.974
0.5%		16.974
0.0%	minimum	16.974

Moments

Mean	18.088873
Std Dev	0.8750328
Std Err Mean	0.3572306
upper 95% Mean	19.007163
lower 95% Mean	17.170582
N	6

Stem and Leaf

Stem	Leaf	Count
19	6	1
19		
19		
19		
18		
18		
18		
18	3	1
18	0	1
17	89	2
17		
17		
17		
17	0	1

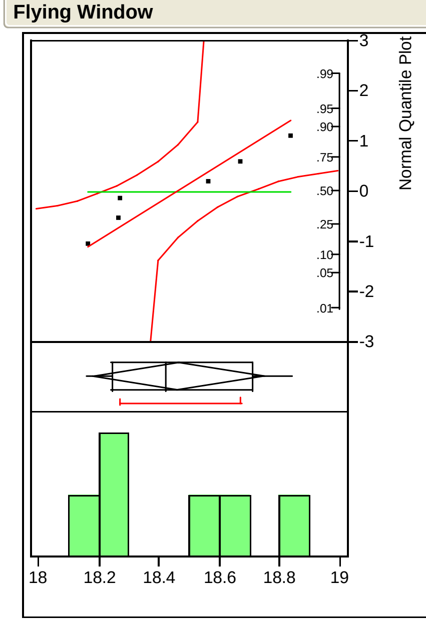
17|0 represents 17.0

Figure 442. Stem and Leaf and Normal Quantile Plot for Treatment 21

Option=3WMF, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

Flying Window



Quantiles

100.0%	maximum	18.841
99.5%		18.841
97.5%		18.841
90.0%		18.841
75.0%	quartile	18.714
50.0%	median	18.423
25.0%	quartile	18.245
10.0%		18.168
2.5%		18.168
0.5%		18.168
0.0%	minimum	18.168

Moments

Mean	18.46624
Std Dev	0.2669347
Std Err Mean	0.1089756
upper 95% Mean	18.746371
lower 95% Mean	18.186109
N	6

Stem and Leaf

Stem	Leaf	Count
188	4	1
187		
187		
186	7	1
186		
185	7	1
185		
184		
184		
183		
183		
182	78	2
182		
181	7	1

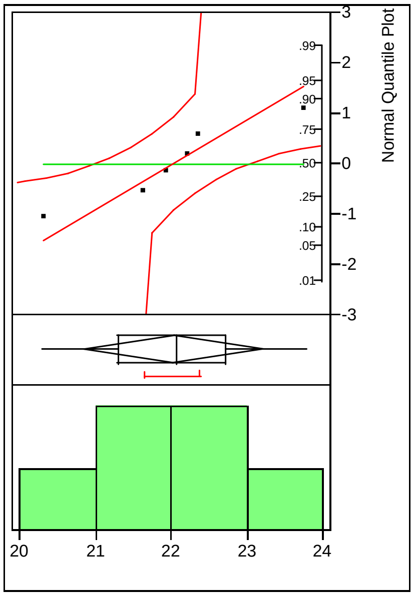
181|7 represents 18.17

Figure 443. Stem and Leaf and Normal Quantile Plot for Treatment 22

Option=3WMF, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

Flying Window



Quantiles

100.0%	maximum	23.768
99.5%		23.768
97.5%		23.768
90.0%		23.768
75.0%	quartile	22.726
50.0%	median	22.087
25.0%	quartile	21.316
10.0%		20.326
2.5%		20.326
0.5%		20.326
0.0%	minimum	20.326

Moments

Mean	22.049041
Std Dev	1.116934
Std Err Mean	0.4559864
upper 95% Mean	23.221192
lower 95% Mean	20.876891
N	6

Stem and Leaf

Stem	Leaf	Count
23	8	1
23		
23		
23		
23		
22		
22		
22	4	1
22	2	1
22		
21	9	1
21	6	1
21		
21		
21		
20		
20		
20		
20	3	1

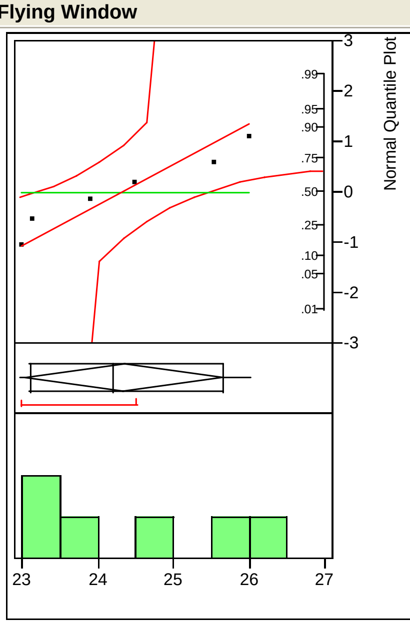
20|3 represents 20.3

Figure 444. Stem and Leaf and Normal Quantile Plot for Treatment 23

Option=3WMF, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

Flying Window



Quantiles

100.0%	maximum	26.010
99.5%		26.010
97.5%		26.010
90.0%		26.010
75.0%	quartile	25.666
50.0%	median	24.212
25.0%	quartile	23.112
10.0%		23.007
2.5%		23.007
0.5%		23.007
0.0%	minimum	23.007

Moments

Mean	24.35638
Std Dev	1.2379325
Std Err Mean	0.5053838
upper 95% Mean	25.65551
lower 95% Mean	23.057249
N	6

Stem and Leaf

Stem	Leaf	Count
26	0	1
25	6	1
25		
24	5	1
24		
23	9	1
23	01	2

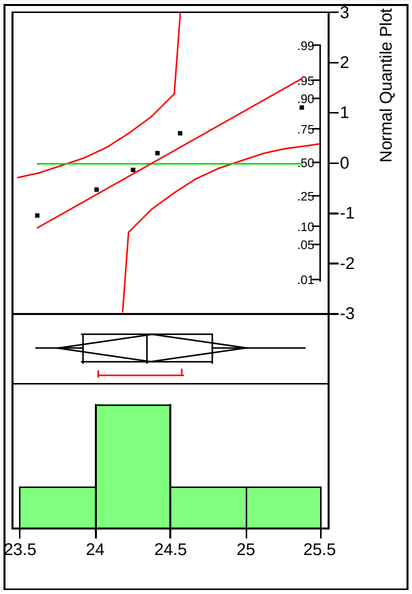
23|0 represents 23.0

Figure 445. Stem and Leaf and Normal Quantile Plot for Treatment 24

Option=3WMF, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

Flying Window



Quantiles

100.0%	maximum	25.387
99.5%		25.387
97.5%		25.387
90.0%		25.387
75.0%	quartile	24.779
50.0%	median	24.345
25.0%	quartile	23.924
10.0%		23.626
2.5%		23.626
0.5%		23.626
0.0%	minimum	23.626

Moments

Mean	24.383741
Std Dev	0.5941515
Std Err Mean	0.2425614
upper 95% Mean	25.007265
lower 95% Mean	23.760217
N	6

Stem and Leaf

Stem	Leaf	Count
253	9	1
252		
251		
250		
249		
248		
247		
246		
245	8	1
244	3	1
243		
242	6	1
241		
240	2	1
239		
238		
237		
236	3	1

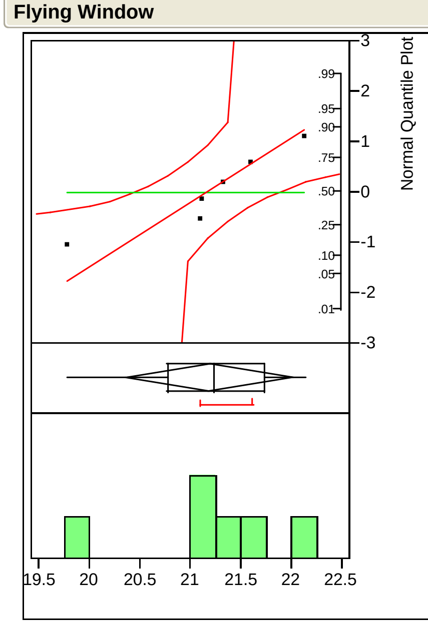
236|3 represents 23.63

Figure 446. Stem and Leaf and Normal Quantile Plot for Treatment 25

Option=3WMF, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

Flying Window



Quantiles

100.0%	maximum	22.137
99.5%		22.137
97.5%		22.137
90.0%		22.137
75.0%	quartile	21.747
50.0%	median	21.235
25.0%	quartile	20.786
10.0%		19.802
2.5%		19.802
0.5%		19.802
0.0%	minimum	19.802

Moments

Mean	21.190075
Std Dev	0.7798669
Std Err Mean	0.3183793
upper 95% Mean	22.008495
lower 95% Mean	20.371655
N	6

Stem and Leaf

Stem	Leaf	Count
22	1	1
21	6	1
21	113	3
20		
20		
19	8	1

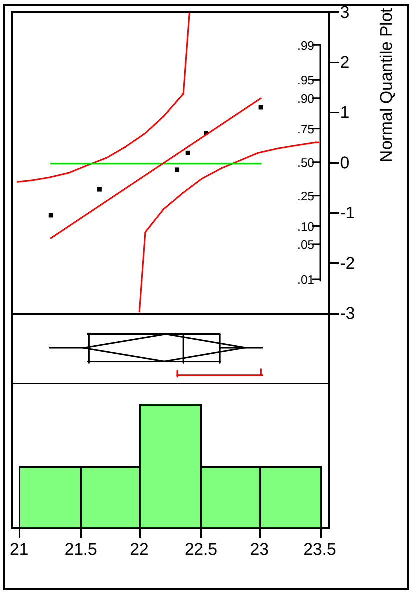
19|8 represents 19.8

Figure 447. Stem and Leaf and Normal Quantile Plot for Treatment 26

Option=3WMF, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

Flying Window



Quantiles

100.0%	maximum	23.011
99.5%		23.011
97.5%		23.011
90.0%		23.011
75.0%	quartile	22.671
50.0%	median	22.364
25.0%	quartile	21.578
10.0%		21.268
2.5%		21.268
0.5%		21.268
0.0%	minimum	21.268

Moments

Mean	22.207647
Std Dev	0.6294969
Std Err Mean	0.2569911
upper 95% Mean	22.868264
lower 95% Mean	21.54703
N	6

Stem and Leaf

Stem	Leaf	Count
230	1	1
229		
228		
227		
226		
225	6	1
224	1	1
223	2	1
222		
221		
220		
219		
218		
217		
216	8	1
215		
214		
213		
212	7	1

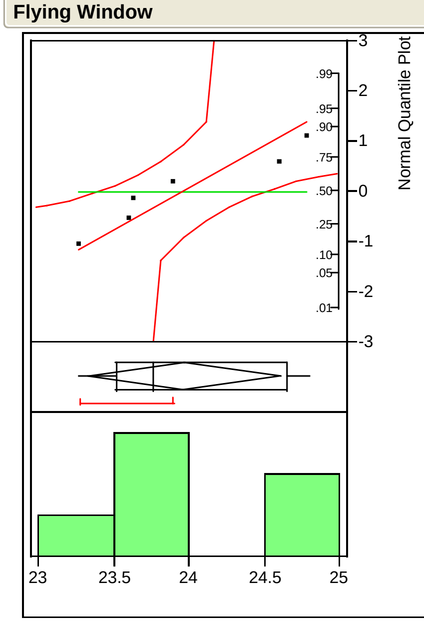
212|7 represents 21.27

Figure 448. Stem and Leaf and Normal Quantile Plot for Treatment 27

Option=3WMF, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

Flying Window



Quantiles

100.0%	maximum	24.796
99.5%		24.796
97.5%		24.796
90.0%		24.796
75.0%	quartile	24.658
50.0%	median	23.772
25.0%	quartile	23.527
10.0%		23.279
2.5%		23.279
0.5%		23.279
0.0%	minimum	23.279

Moments

Mean	23.973417
Std Dev	0.6023802
Std Err Mean	0.2459207
upper 95% Mean	24.605576
lower 95% Mean	23.341258
N	6

Stem and Leaf

Stem	Leaf	Count
248	0	1
247		
246	1	1
245		
244		
243		
242		
241		
240		
239	0	1
238		
237		
236	14	2
235		
234		
233		
232	8	1

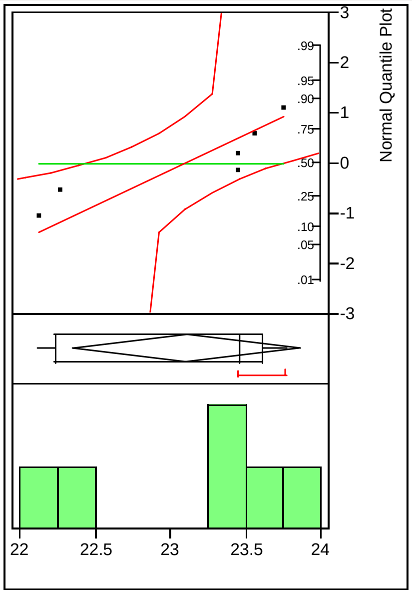
232|8 represents 23.28

Figure 449. Stem and Leaf and Normal Quantile Plot for Treatment 28

Option=3WMF, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

Flying Window



Quantiles

100.0%	maximum	23.766
99.5%		23.766
97.5%		23.766
90.0%		23.766
75.0%	quartile	23.618
50.0%	median	23.461
25.0%	quartile	22.239
10.0%		22.136
2.5%		22.136
0.5%		22.136
0.0%	minimum	22.136

Moments

Mean	23.110946
Std Dev	0.7123086
Std Err Mean	0.2907988
upper 95% Mean	23.858468
lower 95% Mean	22.363424
N	6

Stem and Leaf

Stem	Leaf	Count
237	7	1
236		
235	7	1
234	66	2
233		
232		
231		
230		
229		
228		
227		
226		
225		
224		
223		
222	7	1
221	4	1

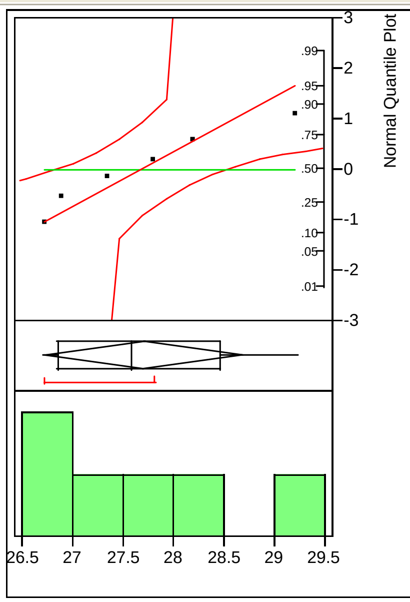
221|4 represents 22.14

Figure 450. Stem and Leaf and Normal Quantile Plot for Treatment 29

Option=3WMF, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

Flying Window



Quantiles

100.0%	maximum	29.224
99.5%		29.224
97.5%		29.224
90.0%		29.224
75.0%	quartile	28.464
50.0%	median	27.589
25.0%	quartile	26.863
10.0%		26.733
2.5%		26.733
0.5%		26.733
0.0%	minimum	26.733

Moments

Mean	27.708676
Std Dev	0.9246682
Std Err Mean	0.3774942
upper 95% Mean	28.679055
lower 95% Mean	26.738296
N	6

Stem and Leaf

Stem	Leaf	Count
29	2	1
29		
28		
28		
28		
28	2	1
28		
27	8	1
27		
27	4	1
27		
27		
26	9	1
26	7	1

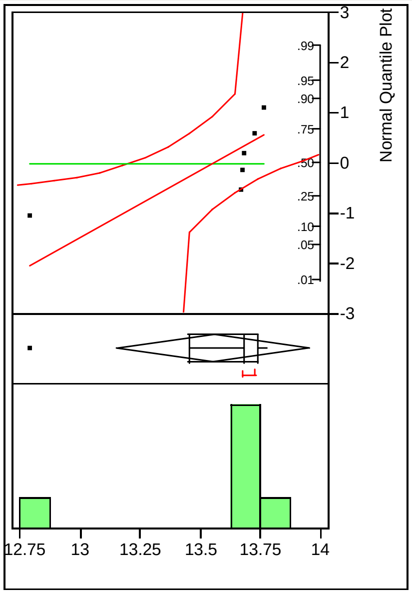
26|7 represents 26.7

Figure 451. Stem and Leaf and Normal Quantile Plot for Treatment 30

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=1_80%

Distributions

Flying Window



Quantiles

100.0%	maximum	13.772
99.5%		13.772
97.5%		13.772
90.0%		13.772
75.0%	quartile	13.740
50.0%	median	13.683
25.0%	quartile	13.455
10.0%		12.795
2.5%		12.795
0.5%		12.795
0.0%	minimum	12.795

Moments

Mean	13.556204
Std Dev	0.374736
Std Err Mean	0.1529853
upper 95% Mean	13.949466
lower 95% Mean	13.162943
N	6

Stem and Leaf

Stem	Leaf	Count
137	37	2
136	788	3
135		
134		
133		
132		
131		
130		
129		
128	0	1

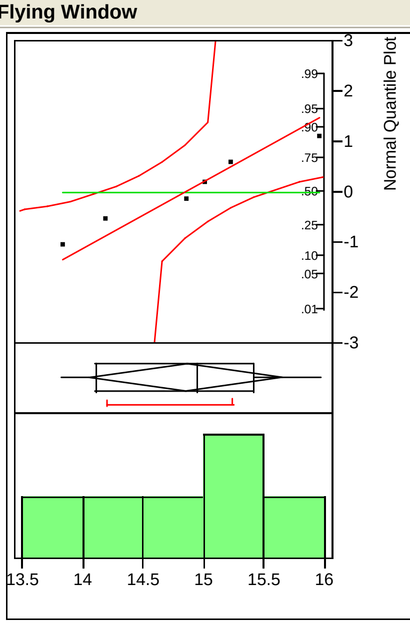
128|0 represents 12.80

Figure 452. Stem and Leaf and Normal Quantile Plot for Treatment 31

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=2_90%

Distributions

Flying Window



Quantiles

100.0%	maximum	15.966
99.5%		15.966
97.5%		15.966
90.0%		15.966
75.0%	quartile	15.419
50.0%	median	14.948
25.0%	quartile	14.114
10.0%		13.846
2.5%		13.846
0.5%		13.846
0.0%	minimum	13.846

Moments

Mean	14.857965
Std Dev	0.7553942
Std Err Mean	0.3083884
upper 95% Mean	15.650703
lower 95% Mean	14.065228
N	6

Stem and Leaf

Stem	Leaf	Count
16	0	1
15		
15	02	2
14	9	1
14	2	1
13	8	1

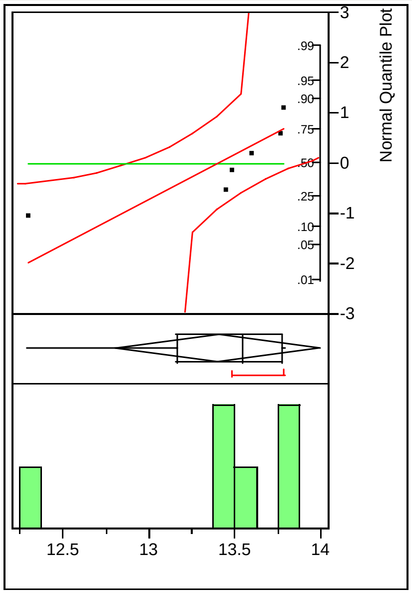
13|8 represents 13.8

Figure 453. Stem and Leaf and Normal Quantile Plot for Treatment 32

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=3_100%

Distributions

Flying Window



Quantiles

100.0%	maximum	13.791
99.5%		13.791
97.5%		13.791
90.0%		13.791
75.0%	quartile	13.781
50.0%	median	13.548
25.0%	quartile	13.168
10.0%		12.305
2.5%		12.305
0.5%		12.305
0.0%	minimum	12.305

Moments

Mean	13.40404
Std Dev	0.5565051
Std Err Mean	0.2271923
upper 95% Mean	13.988056
lower 95% Mean	12.820024
N	6

Stem and Leaf

Stem	Leaf	Count
137	89	2
136	0	1
135		
134	69	2
133		
132		
131		
130		
129		
128		
127		
126		
125		
124		
123	0	1

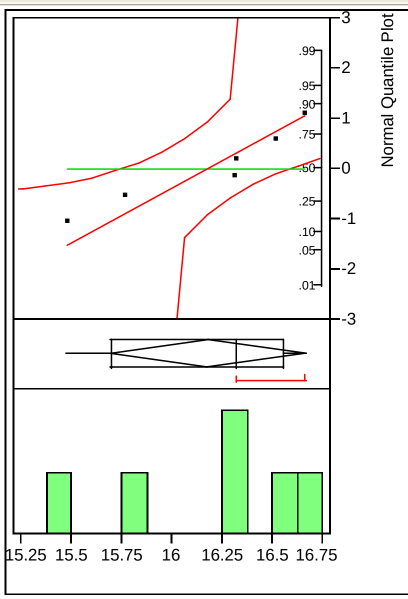
123|0 represents 12.30

Figure 454. Stem and Leaf and Normal Quantile Plot for Treatment 33

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=4_110%

Distributions

Flying Window



Quantiles

100.0%	maximum	16.667
99.5%		16.667
97.5%		16.667
90.0%		16.667
75.0%	quartile	16.563
50.0%	median	16.326
25.0%	quartile	15.702
10.0%		15.487
2.5%		15.487
0.5%		15.487
0.0%	minimum	15.487

Moments

Mean	16.18443
Std Dev	0.4575744
Std Err Mean	0.186804
upper 95% Mean	16.664625
lower 95% Mean	15.704235
N	6

Stem and Leaf

Stem	Leaf	Count
166	7	1
165	3	1
164		
163	23	2
162		
161		
160		
159		
158		
157	7	1
156		
155		
154	9	1

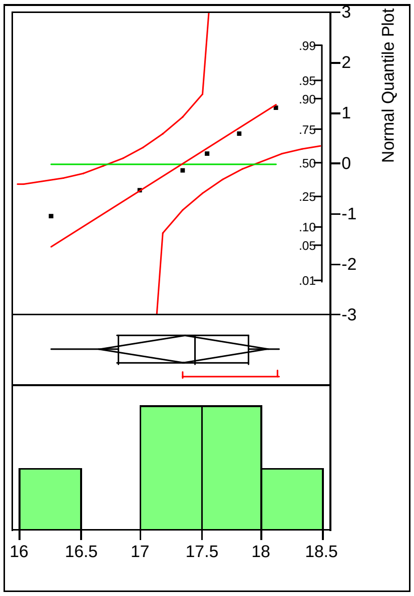
154|9 represents 15.49

Figure 455. Stem and Leaf and Normal Quantile Plot for Treatment 34

Option=3WMR1WF, Time BTW Land TO=2, Sortie Surge=5_120%

Distributions

Flying Window



Quantiles

100.0%	maximum	18.130
99.5%		18.130
97.5%		18.130
90.0%		18.130
75.0%	quartile	17.896
50.0%	median	17.458
25.0%	quartile	16.825
10.0%		16.273
2.5%		16.273
0.5%		16.273
0.0%	minimum	16.273

Moments

Mean	17.357573
Std Dev	0.6558955
Std Err Mean	0.2677682
upper 95% Mean	18.045893
lower 95% Mean	16.669253
N	6

Stem and Leaf

Stem	Leaf	Count
18	1	1
17	8	1
17	6	1
17	4	1
17		
17	0	1
16		
16		
16		
16	3	1

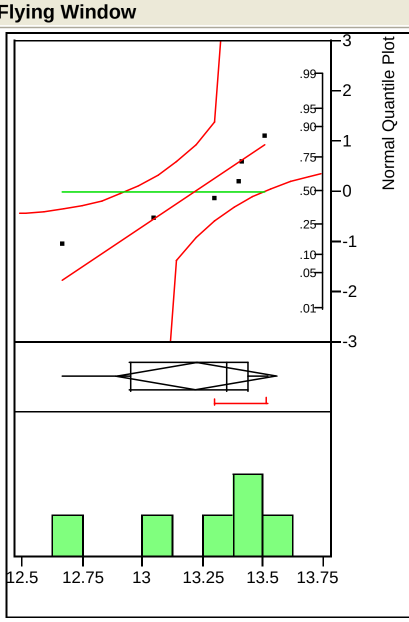
16|3 represents 16.3

Figure 456. Stem and Leaf and Normal Quantile Plot for Treatment 35

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=1_80%

Distributions

Flying Window



Quantiles

100.0%	maximum	13.514
99.5%		13.514
97.5%		13.514
90.0%		13.514
75.0%	quartile	13.441
50.0%	median	13.355
25.0%	quartile	12.957
10.0%		12.674
2.5%		12.674
0.5%		12.674
0.0%	minimum	12.674

Moments

Mean	13.227536
Std Dev	0.3139723
Std Err Mean	0.1281787
upper 95% Mean	13.55703
lower 95% Mean	12.898042
N	6

Stem and Leaf

Stem	Leaf	Count
135	1	1
134	12	2
133	0	1
132		
131		
130	5	1
129		
128		
127		
126	7	1

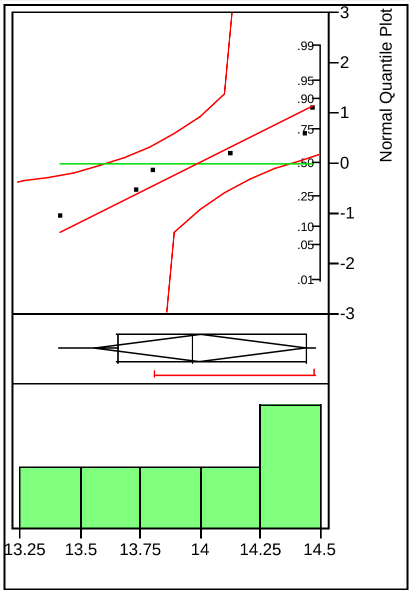
126|7 represents 12.67

Figure 457. Stem and Leaf and Normal Quantile Plot for Treatment 36

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=2_90%

Distributions

Flying Window



Quantiles

100.0%	maximum	14.472
99.5%		14.472
97.5%		14.472
90.0%		14.472
75.0%	quartile	14.446
50.0%	median	13.970
25.0%	quartile	13.658
10.0%		13.423
2.5%		13.423
0.5%		13.423
0.0%	minimum	13.423

Moments

Mean	14.001507
Std Dev	0.4168627
Std Err Mean	0.1701835
upper 95% Mean	14.438978
lower 95% Mean	13.564036
N	6

Stem and Leaf

Stem	Leaf	Count
144	47	2
143		
142		
141	3	1
140		
139		
138	1	1
137	4	1
136		
135		
134	2	1

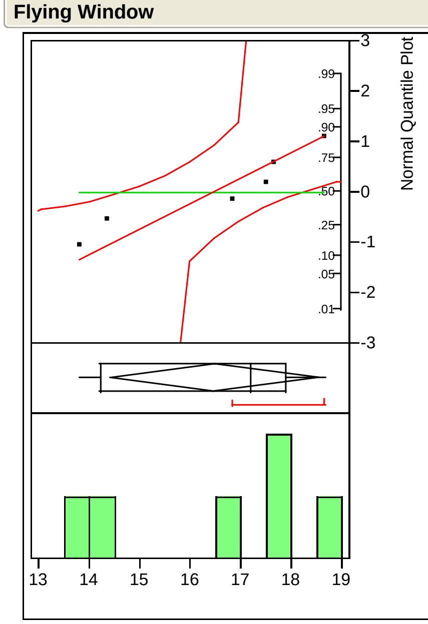
134|2 represents 13.42

Figure 458. Stem and Leaf and Normal Quantile Plot for Treatment 37

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=3_100%

Distributions

Flying Window



Quantiles

100.0%	maximum	18.669
99.5%		18.669
97.5%		18.669
90.0%		18.669
75.0%	quartile	17.918
50.0%	median	17.198
25.0%	quartile	14.234
10.0%		13.836
2.5%		13.836
0.5%		13.836
0.0%	minimum	13.836

Moments

Mean	16.489246
Std Dev	1.9457197
Std Err Mean	0.7943367
upper 95% Mean	18.531153
lower 95% Mean	14.447338
N	6

Stem and Leaf

Stem	Leaf	Count
18	7	1
18		
17	57	2
17		
16	9	1
16		
15		
15		
14		
14	4	1
13	8	1

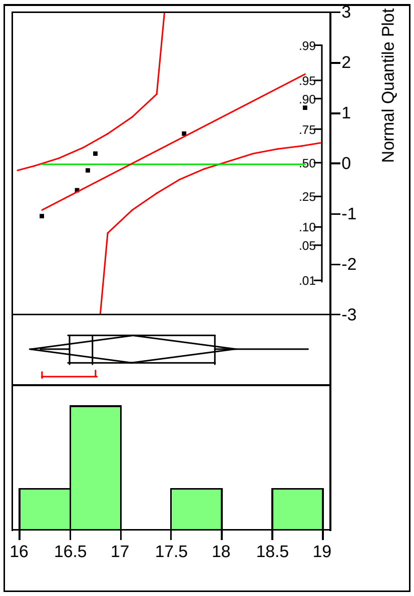
13|8 represents 13.8

Figure 459. Stem and Leaf and Normal Quantile Plot for Treatment 38

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=4_110%

Distributions

Flying Window



Quantiles

100.0%	maximum	18.844
99.5%		18.844
97.5%		18.844
90.0%		18.844
75.0%	quartile	17.941
50.0%	median	16.724
25.0%	quartile	16.494
10.0%		16.232
2.5%		16.232
0.5%		16.232
0.0%	minimum	16.232

Moments

Mean	17.124358
Std Dev	0.9628652
Std Err Mean	0.3930881
upper 95% Mean	18.134823
lower 95% Mean	16.113893
N	6

Stem and Leaf

Stem	Leaf	Count
18	8	1
18		
18		
18		
18		
17		
17	6	1
17		
17		
17		
16	8	1
16	67	2
16		
16	2	1

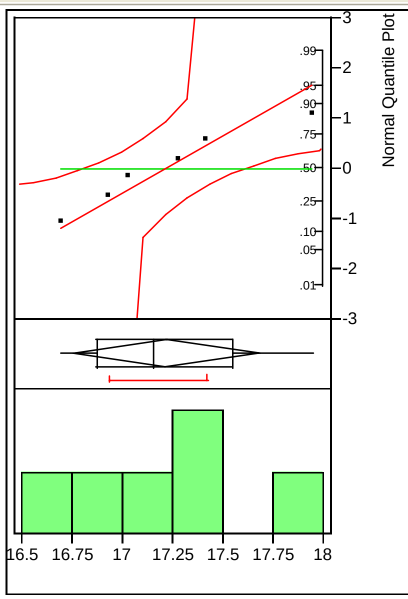
16|2 represents 16.2

Figure 460. Stem and Leaf and Normal Quantile Plot for Treatment 39

Option=3WMR1WF, Time BTW Land TO=3, Sortie Surge=5_120%

Distributions

Flying Window



Quantiles

100.0%	maximum	17.950
99.5%		17.950
97.5%		17.950
90.0%		17.950
75.0%	quartile	17.554
50.0%	median	17.160
25.0%	quartile	16.880
10.0%		16.702
2.5%		16.702
0.5%		16.702
0.0%	minimum	16.702

Moments

Mean	17.222369
Std Dev	0.4380431
Std Err Mean	0.1788304
upper 95% Mean	17.682067
lower 95% Mean	16.762671
N	6

Stem and Leaf

Stem	Leaf	Count
179	5	1
178		
177		
176		
175		
174	2	1
173		
172	9	1
171		
170	4	1
169	4	1
168		
167	0	1

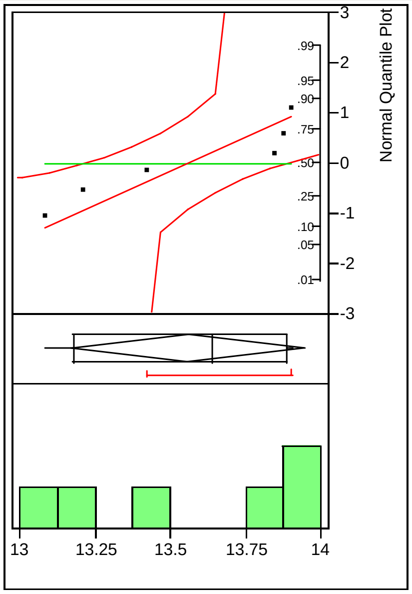
167|0 represents 16.70

Figure 461. Stem and Leaf and Normal Quantile Plot for Treatment 40

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=1_80%

Distributions

Flying Window



Quantiles

100.0%	maximum	13.904
99.5%		13.904
97.5%		13.904
90.0%		13.904
75.0%	quartile	13.887
50.0%	median	13.640
25.0%	quartile	13.182
10.0%		13.090
2.5%		13.090
0.5%		13.090
0.0%	minimum	13.090

Moments

Mean	13.561237
Std Dev	0.3652352
Std Err Mean	0.1491066
upper 95% Mean	13.944528
lower 95% Mean	13.177947
N	6

Stem and Leaf

Stem	Leaf	Count
139	0	1
138	58	2
137		
136		
135		
134	3	1
133		
132	1	1
131		
130	9	1

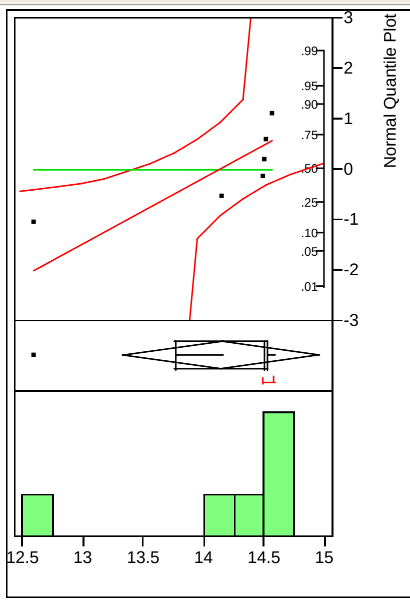
130|9 represents 13.09

Figure 462. Stem and Leaf and Normal Quantile Plot for Treatment 41

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=2_90%

Distributions

Flying Window



Quantiles

100.0%	maximum	14.583
99.5%		14.583
97.5%		14.583
90.0%		14.583
75.0%	quartile	14.538
50.0%	median	14.508
25.0%	quartile	13.771
10.0%		12.611
2.5%		12.611
0.5%		12.611
0.0%	minimum	12.611

Moments

Mean	14.148557
Std Dev	0.7683397
Std Err Mean	0.3136734
upper 95% Mean	14.95488
lower 95% Mean	13.342234
N	6

Stem and Leaf

Stem	Leaf	Count
14	6	1
14	555	3
14	2	1
14		
13		
13		
13		
13		
13		
12		
12	6	1

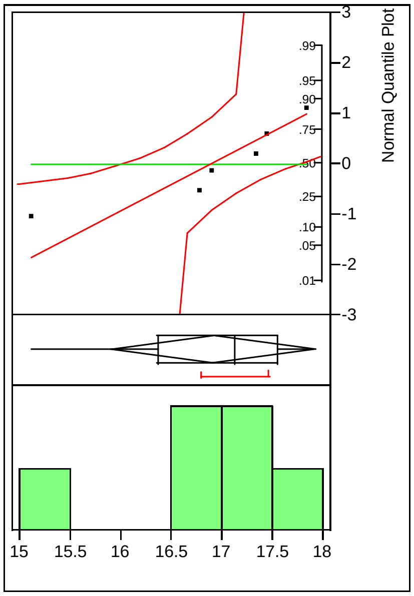
12|6 represents 12.6

Figure 463. Stem and Leaf and Normal Quantile Plot for Treatment 42

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=3_100%

Distributions

Flying Window



Quantiles

100.0%	maximum	17.851
99.5%		17.851
97.5%		17.851
90.0%		17.851
75.0%	quartile	17.560
50.0%	median	17.137
25.0%	quartile	16.384
10.0%		15.134
2.5%		15.134
0.5%		15.134
0.0%	minimum	15.134

Moments

Mean	16.920456
Std Dev	0.9549055
Std Err Mean	0.3898385
upper 95% Mean	17.922568
lower 95% Mean	15.918344
N	6

Stem and Leaf

Stem	Leaf	Count
17	9	1
17		
17	45	2
17		
17		
16	89	2
16		
16		
16		
16		
15		
15		
15		
15		
15	1	1

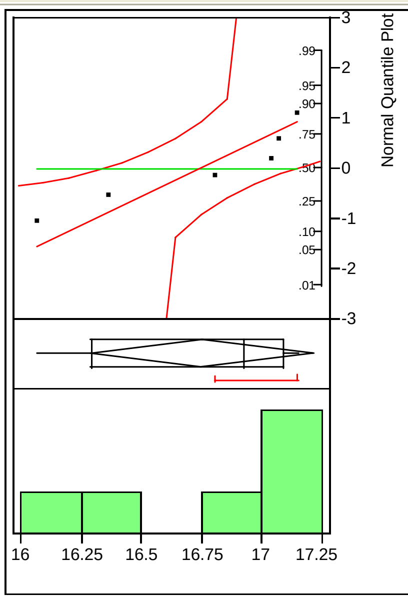
15|1 represents 15.1

Figure 464. Stem and Leaf and Normal Quantile Plot for Treatment 43

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=4_110%

Distributions

Flying Window



Quantiles

100.0%	maximum	17.152
99.5%		17.152
97.5%		17.152
90.0%		17.152
75.0%	quartile	17.095
50.0%	median	16.925
25.0%	quartile	16.296
10.0%		16.074
2.5%		16.074
0.5%		16.074
0.0%	minimum	16.074

Moments

Mean	16.753892
Std Dev	0.4375091
Std Err Mean	0.1786123
upper 95% Mean	17.21303
lower 95% Mean	16.294755
N	6

Stem and Leaf

Stem	Leaf	Count
171	5	1
170	48	2
169		
168	1	1
167		
166		
165		
164		
163	7	1
162		
161		
160	7	1

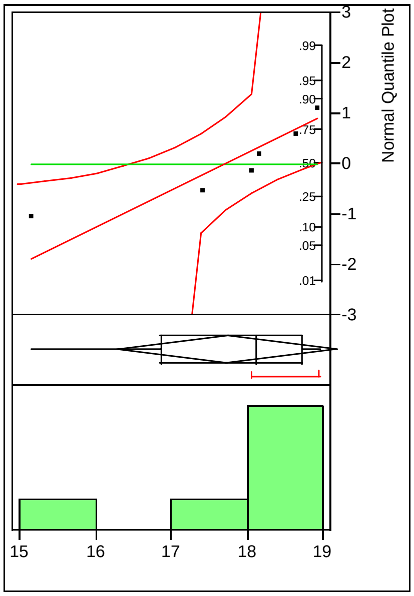
160|7 represents 16.07

Figure 465. Stem and Leaf and Normal Quantile Plot for Treatment 44

Option=3WMR1WF, Time BTW Land TO=4, Sortie Surge=5_120%

Distributions

Flying Window



Quantiles

100.0%	maximum	18.950
99.5%		18.950
97.5%		18.950
90.0%		18.950
75.0%	quartile	18.732
50.0%	median	18.126
25.0%	quartile	16.869
10.0%		15.179
2.5%		15.179
0.5%		15.179
0.0%	minimum	15.179

Moments

Mean	17.745494
Std Dev	1.3612037
Std Err Mean	0.5557091
upper 95% Mean	19.173989
lower 95% Mean	16.316998
N	6

Stem and Leaf

Stem	Leaf	Count
19	0	1
18	7	1
18	12	2
17		
17	4	1
16		
16		
15		
15	2	1

15|2 represents 15.2

Figure 466. Stem and Leaf and Normal Quantile Plot for Treatment 45

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XXVI. Vita

Major Konstantinos Iakovidis was born in 1970 in Kozani, Greece. He completed his basic education in Kozani in 1988 when he entered the Hellenic Air Force Academy / Engineering Dept. He graduated at 1992 with a Bachelor Degree in Aerospace and Mechanical Engineering.

His first assignment in 1992 was at 111 Combat Wing where he worked until 2003. In 111CW he was dealing with maintenance and quality control issues – he hold positions in the 330 Squadron, the Field Maintenance Squadron and the Base Quality Assurance Dept. He was also dealing with various NATO activities such as combined exercises, ACE/ACS training and Immediate Reaction Forces.

From 1992 to 1997 he was also studying as a part time student in the Aristotle University Of Thessaloniki / Informatics Dept and he got his Bachelor Degree in Computer Science.

In 1996 he was trained as an F-16 Aircraft Battle Damage Repair Assessor at Hill AFB, Utah. In year 2001 he returned to the 330 Squadron as the Chief of Maintenance and he served for two years. He graduated from the Hellenic Air Force Staff College just before entering the AFIT Graduate School of Engineering and Management (Department of Operational Sciences) in Aug 2003.

Major Konstantinos Iakovidis is married and has a daughter and a son.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

In the F-16 fighter community it is believed that the flying schedule can make or break a wing's maintenance effort. Nevertheless, there is no published scientific support behind many commonly used maintenance scheduling philosophies. The problem is that a generally accepted overall scheduling philosophy to improve the long term health of the fleet does not exist.

The purpose of this research is tri-fold: to identify the most important scheduling philosophies, to identify the most meaningful metrics that capture the long term health of the fleet and maintenance effectiveness, and to compare the various philosophies using the performance measures to help maintenance managers choose the most appropriate one. A stochastic simulation model was generated to model the sortie generation process, and a full factorial Design of Experiment was used to identify statistically significant differences among the proposed scheduling philosophies. The results of the study show that the "3 waves Monday through Thursday and 1 wave on Friday" maintenance scheduling philosophy seems to outperform the other philosophies regardless of the sortie surge level or the time between landing and take off. This philosophy is also less sensitive than the alternative philosophies in sortie level and time between landing and take-off changes.

15. SUBJECT TERMS

Logistics, Aircraft, Maintenance, Sortie Generation, Simulation, Maintenance Scheduling, Maintenance Philosophies, Arena, Delphi Technique, Design of Experiments, F-16

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